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ROLE OF TECHNOLOGY IN PROMOTING INDUSTRIAL COMPETITIVENESS

HEARINGS

BEFORE THE

SUBCOMMITTEE ON
SCIENCE, TECHNOLOGY, AND SPACE

OF THE

COMMITTEE ON COMMERCE,
SCIENCE, AND TRANSPORTATION
UNITED STATES SENATE

NINETY-EIGHTH CONGRESS

FIRST SESSION

ON

S. 428

TO PROVIDE FOR A STUDY ON ECONOMICALLY STRATEGIC TECHNOLOGIES AND TO IDENTIFY AND PROVIDE FOR THE DEVELOPMENT OF SUCH TECHNOLOGIES

S. 632

ENTITLED THE "FRONTIER TECHNOLOGIES ASSESSMENT ACT"

S. 1286

TO ESTABLISH A PROGRAM TO CONDUCT RESEARCH AND DEVELOPMENT FOR IMPROVED MANUFACTURING TECHNOLOGIES, AND FOR OTHER PURPOSES

JUNE 21 AND 23, 1983

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ROLE OF TECHNOLOGY IN PROMOTING INDUSTRIAL COMPETITIVENESS

TUESDAY, JUNE 21, 1983

U.S. Senate,
Committee on Commerce,
Science, and Transportation,
Subcommittee on Science, Technology, and Space,
Washington, D.C.

The subcommittee met, pursuant to notice, at 9:30 a.m., in room SR-253, Russell Building, Hon. Slade Gorton (chairman of the subcommittee) presiding.

Staff members assigned to these hearings: Cheryl Coodley, professional staff member; and Steven H. Flajser, minority professional staff member.

OPENING STATEMENT BY SENATOR GORTON

Senator Gorton. Welcome to the first of 2 days of hearings on the importance of improving manufacturing in the United States in order to increase our competitiveness and employment capacity. The health of the American economy and the employment of our work force are heavily dependent on the strength of our domestic manufacturing industries.

In 1981, manufacturing provided a quarter of our gross national product, accounted for more than one-fifth of all jobs, and produced $154 billion in goods for export. Our wealth, our high standard of living, and our national security in recent decades have been due in large part to our ability to manufacture a wide range of goods superior to those of our competition.

Today there are disturbing signs for our manufacturing industries. In the past 4 years the number of manufacturing jobs has dropped by 4 million, and production of manufactured goods has fallen by 11 percent.

Imports produced by foreign-based workers captured nearly 8 percent of the domestic market for manufactured goods in 1982 and are expected to capture a higher proportion this year. A negative trade balance of $15 billion for manufactured goods is currently projected for 1983.

In recent years the available equipment and techniques for manufacturing have been improved significantly by technological innovations involving computers, automated machines, and exotic sensors. Yet U.S. industries have been comparatively slow in adopting these innovations. For comparison, only 31 percent of the manufacturing equipment used by U.S. industries is less than 10 years old, while in Japan the figure exceeds 60 percent.

Perhaps because U.S. industry has lagged in adopting new manufacturing technologies, our position as a technological innovator in the field has eroded. A National Academy of Engineering panel, for example, reported earlier this year that the American machine-tool industry is beginning to lose its technological leadership to Japan and West Germany.

The efforts of the Federal Government, universities, and industry to advance our manufacturing technologies and to train the associated skilled work force have been limited and fragmented. We have been told that there are significant gaps in our research which is essential for achieving a technological advantage in manufacturing.

Additional research has been called for in such areas as visual and tactical sensors, machine control, and communication strategies, and human/machine interfaces, and sensor information processing. Our universities, traditionally a major source of scientific and technological innovation, are much less involved in manufacturing than in other fields of engineering.

We have been able to identify only half a dozen universities with strong research and training programs in manufacturing engineering, a narrow base indeed for the extent of technological innovations needed to remain competitive. Major technological innovations may possibly lead to manufacturing equipment with greatly expanded abilities to see and feel.

These capabilities will enable machines to select or reject parts quickly and accurately, make delicate or complete items, relieve humans of dangerous or monotonous tasks, learn and improve performance, and produce a wide variety of products and innovations from the same basic manufacturing facility. The world may well be encountering a revolution in manufacturing as great as that brought about by Henry Ford's adaptation of the assembly line. Those industries and countries able to develop and use these manufacturing methods will have competitive advantages over the rest of the world.

Today we shall hear testimony on the importance of manufacturing and on Federal policies for increasing competitiveness through technological innovation.

The hearings will continue on June 23 when the committee will consider bills related to this issue. Among these bills is the Manufacturing Sciences and Technology Research and Development Act of 1983, S. 1286, which I recently introduced along with six of my colleagues.

That bill's purpose is to help restore American technological leadership in manufacturing through reinvigorated university research with shared participation in funding on the part of industry.

[The bills follow:]

II

98th CONGRESS
1st Session

S. 428

To provide for a study on economically strategic technologies and to identify and provide for the development of such technologies.

IN THE SENATE OF THE UNITED STATES

February 3 (legislative day, January 25), 1983

Mr. Tsongas (for himself, Mr. Riegle and Mr. Gorton) introduced the following bill; which was read twice and referred to the Committee on Commerce, Science, and Transportation

---

A BILL

To provide for a study on economically strategic technologies and to identify and provide for the development of such technologies.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Economically Strategic Industrial Research and Development Act".

FINDINGS

Sec. 2. The Congress finds that—

(1) technology development is vital to the United States economy;

(2) industries engaged in technology development contribute greatly to economic growth, have a growth rate twice the growth rate of total industrial output, and make a positive contribution to an otherwise negative manufacturing trade balance;

(3) technological innovation is key to the efforts of basic industries to improve productivity;

(4) United States technology is experiencing strong competitive challenges internationally which have resulted in a world-wide decline in market share for high technology industries in the United States;

(5) intensive targeted research and development plans of other countries are shifting technological advantage overseas in selected fields and may limit development of valuable long-term technology markets by United States industry;

(6) the development of economically strategic technologies, in areas including microelectronics, materials development, biotechnology, robotics, manufacturing processes, and artificial intelligence, offers great potential benefits to the economy;

(7) the riskiness of long-term research and development efforts and the growth of foreign research and development programs require a vigorous Federal role in technology development;

(8) assessing the adequacy of current Federal research and development activities and spending priorities requires—

(A) identification of economically strategic technologies by the science and engineering community;

(B) reliable assessment of research and development activity in other countries on economically strategic technologies;

(C) assessment of efforts in the United States, including industrial, academic, nonprofit, State, Federal, defense, and nondefense research and development activity; and

(D) consideration of competitive strategy in attaining maximum benefit from development of economically strategic technologies;

(9) a plan for the development of economically strategic technologies can best be developed by industry, the academic community, and government, with each committing appropriate resources to maximize the potential for successful development; and

(10) the National Academy of Sciences, including the Institute of Medicine, and the National Academy of Engineering are representative of the science and engineering community, including members from industry,

educational institutions, and government, and are well suited to identify economically strategic technologies and recommend technology development plans.

PURPOSES

SEC. 3. It is the purpose of this Act to—

(1) develop a widespread consensus within the industrial and academic research community as to what technologies are economically strategic for development;

(2) collect the best available data on research and development efforts on economically strategic technologies in the United States and abroad and provide an authoritative comparative analysis of the efforts;

(3) create a forum for the formulation of technology development programs which will include industry, academic, and governmental efforts and resources;

(4) develop technology development programs that include consideration of the comparative position of the United States and appropriate competitive strategy for development; and

(5) authorize appropriations that are sufficient to implement such programs.

DEFINITIONS

SEC. 4. For purposes of this Act—

(1) the term "Director" means the Director of the Office of Science and Technology Policy;

(2) the term "Academies" means the National Academy of Sciences (including the Institute of Medicine and any other unit of the Academy) and the National Academy of Engineering.

THE STUDY ON ECONOMICALLY STRATEGIC TECHNOLOGIES

SEC. 5. Within six months after the date of enactment of this Act, the Director of the Office of Science and Technology Policy shall enter into an agreement with the National Academy of Sciences (including the Institute of Medicine and any other appropriate unit of the National Academy of Sciences) and the National Academy of Engineering under which the Academies shall make a full and complete study that identifies economically strategic technologies and plans for the optimal development of such technologies. The agreement shall include provisions for the coordination of the study between the Academies and a committee for making reports required by section 6(c).

FUNCTIONS OF THE ACADEMIES IN CARRYING OUT THE STUDY

SEC. 6. (a) In designating technologies as economically strategic technologies, the Academies shall—

(1) solicit views of private industry and examine evidence of current industrial initiatives;

(2) assess the economic benefit to be gained from each technology including—

(A) a description and estimate of potential market;

(B) job creation potential;

(C) socioeconomic impact;

(D) potential for declining product cost;

(E) potential for followup and spinoff product development;

(F) evidence of potential widespread industrial application; and

(G) potential for new business formation;

(3) determine the current effort for technology development by Federal and State government including spending levels for defense and nondefense research and development, the nature of the development program, and the potential for transfer of defense technologies to nondefense use;

(4) prepare a summary of existing and projected levels of research and development activity by private industry for each technology;

(5) determine current levels of research and development effort by foreign nations for each technology

and assess the stage of development and the competitive strategy being employed by other nations;

(6) consider the competitive potential of United States industry for future markets, the relative benefits of lead versus followup development, and competitive risks involved such as the potential for development of over capacity or external costs;

(7) assess the technological feasibility of development and the risk for each technology;

(8) consider the necessary time for development of each technology, focusing on technologies with a medium-term development horizon of five to eight years; and

(9) consider the potential economic benefit of the technology and evidence that United States industry will fail to realize such benefits in the absence of an enhanced technology development program.

(b) The Academies shall develop a technology development program for each technology designated as economically strategic. The Academies shall establish an advisory committee composed of industry and academic experts to make recommendations for each such program. The terms of compensation for expenses or service, if any, for such members shall be included in the agreement made pursuant to section 5. Each technology development program shall describe the strategy for development and recommend—

(1) participants in the program and program responsibilities;

(2) levels of effort and financial commitment for each participant and program totals;

(3) timetable of milestones and budget outlays;

(4) appropriate licensing and patent arrangements for participants and nonparticipants, giving equal weight to fair financial return to participants and rapid technology transfer and diffusion;

(5) policy action or spending required of the Federal Government, including recommendations for additional Federal funding with an explanation of the obstacles in finding financing from private sources and a designation of appropriate Federal agencies to participate in the development program and to dispense Federal funds; and

(6) methods for encouraging participation by small business in the technology development program.

(c) The committee, established in accordance with the agreement made pursuant to section 5, shall submit to the President and to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Science and Technology of the House of Representatives interim reports of each technology development program formulated for each designated economically strategic technology, an annual report at the end of each calendar year summarizing the activities of the Academies regarding the study, and not later than three years after the date of enactment of this Act, a final report of the study together with recommendations, including recommendations for legislation.

ADMINISTRATIVE PROVISIONS

SEC. 7. (a) The Academies may, for the purpose of carrying out the provisions of this Act, hold such hearings and consult with such representatives in the business community, educational institutions, Federal, State, and local governments, and other organizations, associations, and individuals as the President of the National Academy of Sciences or the President of the National Academy of Engineering deems advisable.

(b) Each department, agency, and instrumentality of the executive branch of the Federal Government, including independent agencies, is authorized and directed to furnish to the Academies, upon request made by the President of the National Academy of Sciences or the President of the National Academy of Engineering any information such President deems necessary to carry out the study.

AUTHORIZATION OF APPROPRIATIONS

SEC. 8. There are authorized to be appropriated such sums as may be necessary to carry out the study required by this Act and to implement the technology development programs recommended in the study.

II

98TH CONGRESS
1ST SESSION

S. 632

Entitled the "Frontier Technologies Assessment Act".

IN THE SENATE OF THE UNITED STATES

MARCH 1 (legislative day FEBRUARY 23), 1983

Mr. BENTSEN introduced the following bill; which was read twice and referred to the Committee on Commerce, Science, and Transportation

---

A BILL

Entitled the "Frontier Technologies Assessment Act".

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Frontier Technologies Assessment Act."

SECTION 1. SHORT TITLE.

This Act may be cited as the "Frontier Technologies Assessment Act."

SEC. 2. ESTABLISHMENT OF A TASK FORCE ON FRONTIER TECHNOLOGIES.

The President shall appoint a Task Force on Frontier Technologies within sixty days of enactment of this Act.

(a) MEMBERSHIP.—

(1) The Vice President of the United States shall serve as Chairman of the Task Force.

(2) The President shall appoint twenty-four members in addition to the Vice President, including representatives from the private sector, academia, and government, four Senators to be appointed by the Majority Leader of the United States Senate and four Congressmen to be appointed by the Speaker of the United States House of Representatives.

(b) TERM.—All members of the Task Force shall serve until the Task Force reports to Congress pursuant to section 3.

SEC. 3. DUTIES OF TASK FORCE.

The task force shall prepare a report to Congress within one year of the date of enactment of this Act.

(a) The report shall—

(1) summarize all government programs in technologically-mature economies designed to encourage, subsidize, accelerate, or otherwise enhance the pace with which technology research and development occurs;

(2) evaluate the components and success of such government programs, including any role played by tariffs and other barriers to the free exchange across national boundaries of goods and services;

(3) evaluate in conjuction with representatives of the private sector whether such foreign government programs could and should be adopted for use by the Federal Government;

(4) provide a detailed review, including stage of development and potential market prospects, for the specific technologies which are the focus of these foreign government programs; and

(5) evaluate and discuss specific frontier technologies which could form the basis for substantial commercial product lines in the 1990's and beyond, and propose options for exploring the eventual commercial viability of such frontier technologies, involving the Federal Government, the private sector, or academic entities.

(b) Catalog of Federal Research and Development Programs. The report shall contain a compilation and summary of all Federal research or development projects, and private projects where feasible, which focus on technologies which are the subject of foreign government programs summarized in paragraph (a)1, or evaluated in paragraph (a)5.

SEC. 4. AUTHORIZATION.

There is hereby authorized to be appropriated such funds as are necessary to carry out the duties of the Task Force established by this Act.

II

98TH CONGRESS
1ST SESSION

S. 1286

To establish a program to conduct research and development for improved manufacturing technologies, and for other purposes.

IN THE SENATE OF THE UNITED STATES

MAY 16, 1983

Mr. GORTON (for himself, Mr. GOLDWATER, Mr. TRIBLE, Mr. HEFLIN, Mr. RIEGLE, Mr. LAUTENBERG, and Mr. TSONGAS) introduced the following bill; which was read twice and referred to the Committee on Commerce, Science, and Transportation

---

A BILL

To establish a program to conduct research and development for improved manufacturing technologies, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Manufacturing Sciences and Technology Research and Development Act of 1983".

FINDINGS

SEC. 2. The Congress finds that—

(1) various sectors of private industry, the Federal Government, and the United States research establishment have not devoted sufficient attention to research

on developing new processes and methods to improve the Nation's capability to manufacture goods;

(2) while manufacturing industries are essential to the economic well-being of the Nation, many manufacturing processes and methods are no longer capable of producing goods as reliable and cost-competitive as those produced by foreign industries which utilize modern manufacturing methods and processes;

(3) domestic manufacturing is increasingly threatened by external competition and the development by foreign countries of more efficient manufacturing processes and technologies;

(4) outdated manufacturing methods and processes result in higher costs and goods and services of inferior quality, which place great burdens on consumers of such goods and services;

(5) outdated and inefficient manufacturing processes hinder domestic commerce;

(6) transportation and delivery of manufactured goods are vital components of the Nation's interstate commerce, and a decline in consumption of domestic manufactured goods due to inefficient manufacturing processes produces a resultant decline in transportation;

(7) manufacturing contributes large amounts of revenue to the Nation's gross domestic product and employs more than one-fifth of the Nation's work force;

(8) domestic manufacturers have not sufficiently utilized such recent technological changes in manufacturing as programable automation, robotics, advanced sensors, and computer-assisted design and manufacturing; and

(9) a program to conduct research which will produce more efficient manufacturing processes and methods and to encourage research utilization would strengthen commerce and be beneficial to the Nation's consumers.

PURPOSE

SEC. 3. It is the purpose of this Act to establish a program for conducting research which will produce more efficient manufacturing technologies and for conducting research utilization activities to encourage widespread adoption of these technologies.

DEFINITIONS

SEC. 4. As used in this Act, the term—

(1) "Advisory Committee" means the Manufacturing Sciences and Technology Enhancement Advisory Committee established under section 8 of this Act;

(2) "consortia" means a group of organizations such as States, individual industries or industry associations, nonprofit research institutions, and universities and other academic institutions;

(3) "Center" means a Center for Manufacturing Research and Technology Utilization established under section 5(c) of this Act;

(4) "Office" means the Office of the Assistant Secretary for Productivity, Technology and Innovation within the Department of Commerce; and

(5) "Secretary" means the Secretary of Commerce.

GRANTS AND COOPERATIVE AGREEMENTS

SEC. 5. (a) PURPOSES.—The Secretary, through the Office, may award grants and enter into cooperative agreements in accordance with the provisions of this section to provide for research on methods of producing more efficient manufacturing processes and methods, including—

(1) computer-assisted design;

(2) automated materials handling, processing, and assembly;

(3) automated testing;

(4) machine adaptive learning;

(5) integrated manufacturing systems, including interface of automated machines with automated and

nonautomated machines, with production and design personnel, and with other systems (including testing devices, design systems, and inventory control systems);

(6) machine and process control strategies;

(7) automated sensing for machine and process control and product testing;

(8) practices and activities to implement improved manufacturing methods; and

(9) such other research as the Secretary determines to be consistent with the purposes of this Act.

(b) GRANTS.—(1) The Secretary, through the Office, may make grants to provide for research to increase the amount of fundamental scientific and technological knowledge in fields relevant to manufacturing methods and processes. Such grants shall be made on a competitive basis to applicants who comply with such criteria as are specified in this Act and as the Secretary shall establish, consistent with the purposes of this Act.

(2) A recipient of such a grant may be affiliated with a nonprofit research institution, a private industry or industry association, a university or college, a Center established pursuant to subsection (c) of this section, or any other organization which the Secretary considers appropriate. Any such recipient shall not be required to provide any part of the costs

of such research, unless the recipient desires to expand the scope of the research to be conducted. In such case, the Secretary may enter into an agreement which provides for cost sharing by the recipient.

(3) There are authorized to be appropriated for the purposes of this subsection not to exceed $10,000,000 for the fiscal year ending September 30, 1984, not to exceed $20,000,000 for the fiscal year ending September 30, 1985, and not to exceed $30,000,000 for each of the fiscal years ending September 30, 1986, September 30, 1987, and September 30, 1988. Such funds shall remain available until expended.

(c) COOPERATIVE AGREEMENTS.—(1) The Secretary, through the Office, may enter into cooperative agreements for the purpose of establishing and supporting Centers for Manufacturing Research and Technology Utilization. Such Centers shall conduct research of a more applied nature than the research conducted under subsection (b) of this section. Centers shall study methods of increasing the utilization by the Nation's industries of those modern manufacturing methods which may result in lower production costs and improved product quality and reliability. Such research may be directed toward problems or processes and methods appropriate to a specific industrial sector, including aerospace, microelectronics, mechanical assembly, basic materials, new materials, and transportation.

(2) The Secretary shall enter into any such agreements with consortia of research organizations and manufacturing industries or industry associations. Such agreements shall be made with applicants who comply with such criteria as are specified in this Act and as the Secretary shall establish, consistent with the purposes of this Act.

(3)(A) In addition to funds received under this subsection, a Center may receive funds from Federal agencies and from public and private organizations. Consortia which enter into such an agreement shall provide support and participation in a dollar amount at least equal to the amount of the Federal contribution to be made under this subsection.

(B) For purposes of this paragraph, the term "support and participation" includes cash or equipment contributions in an amount equal to at least 50 per centum of the Federal Government's share, industry personnel to conduct research, and access by persons in the research organizations to modern manufacturing equipment in the participating industry for research and other appropriate purposes. Contributions from nonprofit participants may consist of in-kind contributions. Federal contributions made under this subsection may be utilized only to support expenditures by nonprofit research organizations participating in the relevant consortia.

(4) In entering into such agreements, the Secretary shall consider—

(A) the quality of the research which is to be undertaken as a result of the particular agreement;

(B) the extent of participation by industry in the research to be undertaken as a result of the agreement;

(C) the size of the industrial sector involved and the potential impacts on the productivity of that industrial sector as a result of successful research undertaken through the agreement, as well as the subsequent development and utilization of the manufacturing methods and processes to be studied as part of such research; and

(D) the extent to which entering into the agreement would be likely to increase the number of scientific and technical personnel capable of utilizing modern manufacturing methods and processes.

In addition, the Secretary shall insure diversity among the industrial sectors which are the subject of the research conducted under any such agreement, as well as geographic dispersion of the Centers established and supported under this subsection.

(5) There are authorized to be appropriated for the purposes of this subsection not to exceed $5,000,000 for the fiscal year ending September 30, 1984, not to exceed

$15,000,000 for the fiscal year ending September 30, 1985, and not to exceed $25,000,000 for each of the fiscal years ending September 30, 1986, September 30, 1987, and September 30, 1988. Such funds shall remain available until expended.

ADVANCED MANUFACTURING METHODS RESEARCH UTILIZATION PROGRAM

SEC. 6. (a) ACTIVITIES.—The Secretary shall establish a program of experimental activities, and shall evaluate existing activities, to identify the most feasible means of enhancing the utilization of technologically advanced manufacturing methods by retraining workers who have been displaced from declining industries. The Secretary shall provide for the development, conduct, and evaluation of such experimental activities. The Secretary may, to the extent provided in advance in appropriation Acts, contract with any appropriate person or organization (including States and Centers established under section 5(c) of this Act) to carry out such experimental activities.

(b) REPORT.—Not later than one year after the conclusion of the program carried out under this section, the Secretary shall submit to the Congress a report on such program.

(c) AUTHORIZATION.—There are authorized to be appropriated for the purposes of this section not to exceed $4,000,000 for the fiscal year ending September 30, 1984, and not to exceed $10,000,000 for the fiscal year ending September 30, 1985. Such funds shall remain available until expended.

COMPETITIVENESS STUDIES

SEC. 7. (a) STUDY.—The Secretary shall select specific domestic technology-sensitive industrial sectors and shall analyze such sectors' long-term capability for remaining competitive, especially with industries in foreign countries. In making such selection, the Secretary shall consider industrial sectors which are or are likely to be vulnerable to foreign competition, as well as sectors which are likely to experience rapid and significant growth.

(b) SUBJECTS OF STUDY.—As part of such study, the Secretary shall consider—

(1) the adequacy of technologies utilized to produce the goods and services of such sectors;

(2) superior foreign technologies or unique resources which yield a competitive advantage to industries in foreign countries over similiar domestic industries;

(3) the anticipated scientific and technical personnel requirements for such sectors;

(4) the adequacy of Federal laws and requlations, and the enforcement of such laws and regulations, in

promoting technological innovativeness and commercial competitiveness by such sectors; and

(5) whether changes in such laws and regulations, or the enforcement of such laws and regulations, are desirable to promote technological innovation and competition in such sectors and to safeguard the well-being of the Nation and the public

(c) AUTHORIZATION.—There are authorized to be appropriated for the purposes of this section not to exceed $1,000,000 for the fiscal year ending September 30, 1984, and not to exceed $2,000,000 for each of the fiscal years ending September 30, 1985, September 30, 1986, September 30, 1987, and September 30, 1988. Such funds shall remain available until expended.

ADVISORY COMMITTEE

SEC. 8. (a) ESTABLISHMENT.—The Secretary shall establish a Manufacturing Sciences and Technology Enhancement Advisory Committee to advise the Secretary concerning the activities to be conducted under this Act. The Advisory Committee shall have representation from technology-sensitive industrial sectors, from labor, from the manufacturing research community, and from other sectors which the Secretary considers appropriate. Such members shall be appointed by the Secretary for a term of two years, and shall receive no compensation. Any such member shall, in accordance with section 5703 of title 5, United States Code, be entitled to reimbursement for travel or transportation expenses incurred in the performance of responsibilities as a member of the Advisory Committee.

(b) FUNCTIONS.—The Advisory Committee shall—

(1) review the policies and selection criteria for grants made and cooperative agreements entered into under this Act;

(2) review the progress of the Secretary of Commerce in meeting all the requirements of this Act;

(3) assess the effectiveness of the activities funded pursuant to this Act; and

(4) submit to the Secretary, at least annually, evaluations and recommendations regarding activities carried out under this Act.

(c) REPORT.—The Advisory Committee shall submit to the Congress an annual report on its activities under this Act.

(d) APPLICABILITY.—The Advisory Committee shall be subject to the Federal Advisory Committee Act (5 U.S.C. App. 1 et seq.).

Senator GORTON. We will change somewhat the order of presentation today and start with the Honorable Mr. Lionel Olmer, Under Secretary for International Trade in the Department of Commerce, who I understand is accompanied by Dr. Merrifield.

Secretary Olmer.

STATEMENT OF LIONEL OLMER, UNDER SECRETARY FOR INTERNATIONAL TRADE, DEPARTMENT OF COMMERCE, ACCOMPANIED BY DR. E. BRUCE MERRIFIELD, ASSISTANT SECRETARY FOR PRODUCTIVITY, TECHNOLOGY, AND INNOVATION

Mr. OLMER. Thank you, Mr. Chairman. Mr. Merrifield is the Assistant Secretary for Productivity, Technology, and Innovation and will be prepared to answer, in any detail that you care, your questions about some of our programs to aid the process of innovation and technological improvements in the manufacturing process.

I am very pleased to be here to talk about the role of technology in promoting industrial competitiveness, and I have prepared a rather lengthy statement with accompanying graphs and charts that I would like to introduce for the record.

Senator GORTON. It will be included in the record as if read in full.

Mr. OLMER. I would briefly summarize that subject at the present time. The topic in our view presents an enormous challenge to America and great opportunities for the long-term economic health of the country.

Following World War II, the productive capacity of the United States relative to the rest of the industrial world gave us the ability to compete successfully and dominantly in almost every market and in almost every single product area. Over time, however, the industrial economies of Europe and Japan have rebuilt, recovered, and have begun to increase their market share relative to the United States in virtually every product category and in virtually every single geographic market.

In addition, the developing countries were building up their industrial sectors to the point where they now challenge us in a number of product areas and challenge us very seriously indeed. While these trends may be good for the world's economy, the constantly changing international situation provides a very serious challenge to our own economic objectives.

Manufactures continue to be the basis of our economy and of our foreign trade despite all of the talk about the new importance of the services sector. Manufacturing, as a share of total U.S. output, is about 24 percent of GNP and has remained essentially stable since 1950, and manufactures, as a share of total exports, have remained stable since about 1963 or at roughly 66 percent.

The U.S. international market share of manufacturing is significantly lower now than it was 20 years ago, but the share has been rising since 1978 and now we are at about 20 percent, reaching 1971 levels again.

The advanced-technology industries play a dual role. They are important in their own right, creating jobs and providing a trade surplus that helps offset deficits in other sectors. In addition, they make a very, very significant contribution to the competitiveness, or the opportunities for competitiveness, I should say, of the so-called smokestack and service industries.

These high-tech industries provide the new processes and the equipment that improve the efficiency and productivity of our manufacturing and service industries, the performance and quality of our products and our responsiveness, if that is what it is to be, of our attitudes toward changing market conditions. That is what competitiveness is really all about.

High-tech industries increasingly require access to and success in world markets in order to achieve economies of scale and to spread the costs and the risks of innovation over more units and to generate the cash flow necessary to create the next generation of products. We in the Commerce Department performed a study last year of the competitiveness of U.S. high-technology industries. The examination resulted in the following conclusions: High-tech industries are absolutely vital to the U.S. economy; national security depends upon technology intensive industries both for sophisticated items essential to modern weapons superiority and for a strong and flexible capability to meet future contingencies; the United States will have to depend heavily on high-tech industries in order to meet increased competition in world markets.

Over the past 12 years, there has been a decline in the international market position of U.S. high-tech industries from a position of dominance to one of being strongly challenged by a number of foreign competitors. Finally, a number of factors influence United States versus foreign advances in technology that tend to apply to all industries and these are: The overall state of the domestic economy; the cost and availability of capital; relative R&D efforts; the issue of transfer of technology; the availability of sufficient numbers of adequately trained and educated scientists and technicians; and finally, explicit foreign industrial policies which target the technology-intensive sectors for development.

Our study predicted that, if present trends continue, some or all of these factors could well contribute to a further significant decline in the competitive position of U.S. high-technology industries. Secretary of Commerce Baldrige decided to take these conclusions to the business community for its assessment.

We sponsored meetings with leading executives of the robotics, computer, semiconductor, telecommunications, and machine-tool industries that were also attended by representatives from other Government agencies concerned with U.S. industrial competitiveness. Four areas of concern emerged as priority issues: Antitrust laws, R&D policies, tax policies, and foreign market access.

I am submitting, for the record, compilations of these discussions.[1] Mr. Chairman, they are bound in these four volumes that we have and a fifth is under preparation now.

Basically, each of these industries said to us we are competitive with anyone anywhere. Just get the Government off our back on the one hand and make the foreigners play by the same rules as we do and we will be OK.

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[1] The publications are for sale by the Superintendent of Documents, U.S. Government Printing Office Washington, D.C. 20402

In general, innovation can be considered as a continuous pipeline having two major stages. The first stage is the invention and the second is translating that invention into a useful commercial product or process.

The large majority of the cost, the risk, and the time, is associated with the second stage. If the national interest requires that the United States maintain world technological leadership, then it is also important to remove barriers to innovation and to provide appropriate incentives for companies to undertake risks.

While Government policy establishes a framework for innovative behavior by the private sector, the private sector has got the major responsibility for managing the translation of technical advances or inventions into the marketplace. I happen to be an advocate of the free flow of technology.

The United States has gained an awful lot from such exchanges, but it is instructive to observe that Japan spent about $10 billion in royalties and fees in the past 30 years to acquire the fruits of research done mostly in the United States. In roughly the same period, U.S. business spent nearly $300 billion.

The cost benefits of licensing and cross-licensing should be a matter of constant review by U.S. companies. I suspect there are a lot of Monday-morning quarterbacks in a lot of companies in America wondering whether or not the sale of a particular technology was truly in their long-term interest.

Industrialized trading nations disagree as to which training practices are trade distorting and unfair. The administration has approached our trading partners in OECD, the Organization for Economic Cooperation and Development, and in the GATT, the General Agreement on Tariffs and Trade, and has requested that these organizations each undertake a study of the issues associated with trade in high technology products.

The OECD has already initiated a work program, and I expect that the GATT will shortly follow. We have also begun bilateral negotiations principally with Japan in the United States/Japan Committee on Industry Related Policies and their effects on trade and second in the United States/Japan Workgroup on High Technology Industries.

From those bilateral and multilateral forums we look forward to long-range prospective solutions and relatively little in the short run. The primary responsibilities, I think I indicated a little earlier, for the management decisions that determine success or failure is squarely on the shoulders of the private sector, and the rapid growth of market share that foreign firms have gained here and in their markets makes for a heavy burden fraught with hazards as well as opportunities.

Mr. Chairman, as a nation we have taken numerous actions to meet these new technological challenges. We seem to have broken the back of inflation, and lowered interest rates are tending to follow.

Tax incentives have been put in place although I believe they need strengthening in certain areas, for example, allowing the 25-percent incremental tax credit for R&D to be applied to startup companies. Congress, the administration and the private sector are working cooperatively to ease the application of antitrust rules on cooperative research and development.

The President's 1984 budget proposes an increase of 17 percent in research and development funding which includes a 10 percent increase for basic research. The administration has included $35 million in the 1984 budget for the National Science Foundation to fund science and math instruction at the secondary school level.

In addition, the administration is proposing an additional $50 million for higher level education and training in technical disciplines including research awards for Ph. D.'s. We have strengthened Federal patent policies to give ownership of inventions developed under Federal contract to the contractor with the expectation that this will provide the incentive for those contractors to increase the commercialization of such inventions.

The Export Trading Company Act removes some antitrust barriers at the marketing end of the innovation pipeline, and we anticipate momentarily issuing the first licenses for the ETC's. The Department of Commerce has initiated a competitive assessment program in such areas as petrochemicals, civil aircraft telecommunications, engineering materials, machine tools, and a few others.

We have also launched, principally due to Dr. Merrifield's enthusiastic expertise, the industrial technology partnership program. In addition to public policy changes, private sector must emphasize the constant search for improvements in productivity, the need for a global strategic planning perspective for the long-term, innovative, labor-management relations and the willingness to adopt new technologies in the workplace.

The challenge is essentially that of anticipating and responding to continuous change. I believe that the United States is well positioned to retain, even to expand, its technological leadership and to strengthen its international competitive position.

We do possess the world's most advanced technology. We have an enviable industrial infrastructure. We have incomparable entrepreneurial talents, and, of course, a large unparalled integrated market.

But increasingly we are going to need to use these resources more effectively and perhaps in a more coordinated fashion, Government and business, in order to withstand the challenges from abroad now and in the future.

Thank you very much, Mr. Chairman. We would be happy to answer any questions.

Senator GORTON. Thank you, Mr. Olmer.

Reports suggest that various U.S. industries are using relatively old manufacturing technologies which hinder their competitiveness. The recent highly publicized business/higher education forum study pointed out that advances in manufacturing technology have been an important element in the increased competitiveness of Japan and Western Europe in such industries as automobiles, aircraft, and agricultural machinery.

A National Academy of Engineering panel reported that U.S. machine-tool technology is beginning to lag in comparison with that of Japan and West Germany. In your testimony you state that the application of certain modern manufacturing technologies like robotics and advanced manufacturing tools could substantially lower certain manufacturing costs which would improve competitiveness.

Has the Department made any assessment of whether American manufacturing technologies or the research supporting these technologies is lagging, as compared to those of foreign countries and industrial sectors which are important to U.S. employment in our economy? Do you have any such studies?

Mr. OLMER. Well, we have done them on a sectoral basis and we have done it generically as regards high technology, and the answer is a very mixed one. In certain areas that you have pointed to, it is our judgment that we are lagging, and lagging seriously, and, as it turns out, when you get the industry representatives in and you talk to them for a long period of time, and I mean by that, you overcome the opening shot of rhetoric, you do find an acknowledgement that there is serious lag in the introduction of new technologies to the manufacturing process.

Anyone who has visited Japan and looked at the machine-tool sector, and visited some firms in the United States, can well understand why there is reason for concern. Japan's capabilities in those areas, I think, are simply awesome.

Now, what can we do about it is another matter.

Senator GORTON. In a sense I guess that is my next question. Does your Department believe that it has any responsibility to stimulate technological regeneration in the industries about which you have expressed these concerns?

Mr. OLMER. Well, the way in which we in this administration see our role may be a little different from those that would argue for a comprehensive Government-erected industrial policy. We don't share that view, but one of the problems with the term industrial policy is that it is not very precisely defined.

I happen to maintain that in many respects we have an industrial policy. Sometimes it is wrong headed and sometimes it may be misplaced or slightly off of the target, but, more to the point, we have a role in educating the private sector in terms of foreign-trade barriers to U.S. exports in those areas in which we are competitive. We have a role to play in educating the private sector in terms of technological advances that are being made by their foreign competitors.

I think we also have a role in supporting the development of better education programs in increasing the speed at which technological innovations can be transferred from the Federal Government to the private sector. By stopping at that point, I don't mean that I have covered the list completely. I guess what I am suggesting is that our role is that of being supportive.

On the one hand, I believe we have a role in removing the shackles from the entrepreneurial capabilities of the private sector, and on the other hand assuring that those companies which are competitive are given their opportunities to succeed in foreign markets because, unless our companies become and are allowed to become globally competitive, they are going to lose here. We can't tolerate a protected home market from which a foreign manufacturer can launch very successful competitive drives for market dominance in the United States.

Senator **Gorton**. To what extent are these problems caused, not by trade barriers and not by what we might call poor management, but simply shortages of appropriately trained and educated people?

Mr. **Olmer**. I think that is a serious problem and according to the numbers that I have looked at it is likely to remain very serious through 1990 in terms of the projected numbers of people educated in the hard sciences that are likely to come out of this. I do believe that the Federal Government has a responsibility to encourage an increase in the number of people entering who are motivated, who are given incentives to come out of high school and go into college and to study the hard sciences.

To give you an example that I think is stellar of the entrepreneurial spirit recognizing the problem and then doing something about it, one of our most competitive industries in my judgment is the semiconductor industry. I think they are the equal or superior of any such industry in the world with some few exceptions in some product categories in which the Japanese have taken the lead.

But the industry recognized the deficiencies of technical talent and about a year ago they began a program called the SRC or the Semiconductor Research Cooperative in which the industry, the companies individually, are targeting a percentage of gross sales for donations to universities that want to sign onto the program. There are roughly $6 billion in about half a dozen universities, Cornell University is principal among them, who will suggest research programs to the industry.

The industry may suggest alternatives or a sharper focus in one area or just may accept it outright. Industries donating equipment and money, and there is roughly $6 billion as I say presently appropriated. It is going to rise to something like $30 billion they hope by 1990.

That is going to do a couple of things. It is going to increase the university level research in two basic areas of interest to the semiconductor industry which is already as I have indicated highly competitive, and second it is going to, I think, encourage more people in those universities to major in the hard sciences and to choose for themselves a career in this very vital industry.

Senator **Gorton**. The administration has recognized the need for industry and the research community to work together to achieve technological progress, for example, in its proposed establishment of a major center for advanced materials at the Lawrence Berkeley Laboratory. Could this be the model for a joint industry research collaboration for fundamental work on robotics and advanced sensors for industrial application that would in time help our manufacturing industries? Do you see this as a prediction of an even larger future?

Mr. **Olmer**. I'm afraid I can't see that far in the future, Senator, but I would like to ask Dr. Merrifield if he would speak to that particular program. I think we would be delighted to see this work as we hope it will and believe it will work.

Senator **Gorton**. We would be happy to hear from Dr. Merrifield.

Dr. **Merrifield**. I think first that we need to understand a little more in detail the nature of technological innovation and the innovation pipeline. When you start with an idea you go through a technical feasibility stage, through a series of development stages, a pilot plan, and a prototype stage before you become full-scale commercial.

Normally it takes 7 to 10 years for a major program to go through this pipeline. Only 1 out of 20 projects that starts out in a laboratory ever produces a positive cash flow. It is a high-risk situation.

Now, we fund pretty heavily those first two steps of this pipeline. We will put about $6.6 billion into basic research, and maybe another $3 billion into applied research in this country next year. That is more than any other country in the world does, but we don't have any incentives for the translation of that research into commercial operation.

Coming back to your point now, I think we do need to continue that basic work, and that is where the Government funding and focus should continue to be to maintain a pool of technology to build upon. But the important point is that we are missing the appropriate incentives to pull that basic technology through to commercial products and processes.

As a result, Japan and Europe and all the countries around the world are now cherry picking a lot of our best technology at those early stages where they are vulnerable and undercapitalized and then they subsidize them. The ceramic engine, for example, was based on our heat shield technology which the Japanese developed.

There are many other examples of this happening, so I think that this is an important objective. Let's focus Federal money on the basic areas, provide incentives for industry to pull that technology through to the commercialization because that is where the ingenious creativity of the marketplace can best be applied. We don't want to invent great mousetraps for which there aren't any mice, and the market place can best discern where they are.

Does that help?

Senator **Gorton**. It certainly does. I thank you very much.

Senator Heflin.

Senator **Heflin**. These hearings are a result of several bills including the chairman of this subcommittee's bill which has been joined by a number of Senators, I believe Senator Lautenberg and myself. There are other bills which are directed as I view it largely to Government's role in the future pertaining to innovative manufacturing approaches and new technologies. I think we have to admit that the human mind is going to move forward whether it be in America or some other country and that we will see robots coming in the future.

We will see lasers developed. We will see further advancements in computers. We will see further advancements of telecommunications and petrochemicals and so on.

Now the purpose of these hearings is to largely ascertain Government's role and from the hearings and debate to develop a policy of the Government role. This can come about by the passage of legislation. I think it is inescapable that we are going to make advances.

Another area I didn't mention is materials processing in space. Where will America be and what will its policy be in the future. As I see it there are several areas.

One, is the area of research and development and the second is the protection of the fruits of the mind, patents and other approaches. The third is in America's role in production and the fourth area will be the spinoff or the byproducts dealing with jobs, with people, their work hours, their work week, and other matters. A good number of these inventions will mean that less human hands will be needed in the overall economy if we move forward in the fields of advanced technology in the future.

So, looking at these areas, I think our focus is to be what is Government's role. There may be other subdivisions but just in my own thinking I put it into those categories.

Now I think primarily we are interested right now in research and development. America in the past has been sort of the center. We have had the ingenuity to move forward and make inventions.

We in effect let other nations share in it. I'm not saying that that is wrong. Sometimes on production they come around and are maybe outdoing America, but first, regarding research on development what is the Government's role?

I suppose we generally come around to the issue of Government's role as to whether or not it should be some type of intervention with the regulatory process in an attempt to do things, or on the other hand whether it is a matter of Government cooperation and providing incentives. Another area of Government's role is when you have something that is massive that private enterprise is not in a position financially to carry out then Government can be involved in the basis research.

There are certain problems as I see it in research and development. One is the question of joint ventures and the question of antitrust laws relative to this. Do you foresee that there is a need relative to industry developing in the future which would in effect allow for joint ventures? If so, do you have any suggestions as to the extent that we ought to pursue these matters?

Mr. Olmer. Well, Senator, I do think that there is a need for some change in the way in which our antitrust law has been interpreted and applied in the area of allowing cooperative research and development efforts to take place. We have an Assistant Attorney General for Anti-Trust, Bill Baxter, who has been quite supportive of the kinds of issues that were raised in that area by these industry representatives. He attended most of these sessions with telecommunications and semiconductors, computers and robotics, and he heard the same story unrehearsed from each of their representatives of their concern for antitrust liability both by the government and by the private sector for any joint R&D that might be undertaken.

As I'm sure you know there is presently a microprocessor cooperative research effort that has begun with some 15 companies, and they are at the present time operating not with full assurance that they will be held harmless from private or government action against them in the antitrust area but with a sufficient assurance to make them go ahead as they have in terms of having selected a state in which to locate and a building and the hiring of people. They are moving forward.

Indeed, Mr. Baxter's interpretation of the law is that it is within the prerogative of the Department of Justice to reach an interpretation that would permit such activity while still protecting the competitive requirements of the Clayton and Sherman Anti-Trust Acts. It is a long and somewhat rambling answer, Senator.

I think that the industry itself would say we don't have sufficient clarity at the present time and in any event all we have is the present administration. What happens when and if it changes?

In consequence of that, we in the Department are working with other government agencies, and I believe we have circulated informally to the Congress some important prospective changes to the antitrust law and so far we have met with some support, a good deal of support in that respect.

Dr. MERRIFIELD. Senator, Senator Gorton earlier commented or asked about the competitiveness of some of our declining industries. There is an old saying that most innovations in a given industry come from outside that industry and there is a good reason for that.

Most of the skills and capabilities that are required in innovation are not captive in the existing industry so that collaborative efforts are essential to maintaining competitiveness in almost any industrial operation. The Japanese have understood this very clearly. They have put together all of the skills and capabilities and all of the disciplines that are necessary to tackle an innovation.

We are inhibited from doing that very effectively by our antitrust laws. At least, the apprehension is so great in industry that very little collaborative effort has ever been undertaken. I think it is very important, as Lionel points out, that we clarify these rules, and it has to be done through legislation. Even the Justice Department can't make a statement that will be accepted by all of the courts for all private sector initiatives.

So I think it is very important that we do this not only in the area of collaborative effort, but for the other side to this coin which is the declining industries and our ability to rationalize them effectively. Particularly in steel, for example, we need to allow at least some of our best plants to survive, which otherwise might be shut down because our antitrust laws apparently inhibit the appropriate rationalization.

Mr. OLMER. If I might add just a word, Senator, on the private sector side there is nothing that the Justice Department can do by way of giving an assurance of holding harmless a cooperative effort. In that area in particular I would think that legislation will be required but that is principally an area for the Justice Department.

We are working with them now, and I think we will be coming up with a package of proposals in that respect.

Senator HEFLIN. In several centers in the United States there are research parks and research centers which basically are a cooperative effort between industry and educational institutions. There is a growing feeling that additional research parks might be created in different areas where there may be a concentration of a type of industry and local universities and national universities are brought together.

Do you envision a role for cooperation of universities and industries with emphasis on how a research park or a centralized approach within a geographical location might be of aid in research and development of new innovative ideas?

Mr. OLMER. Senator, that is an area in which in my view the Federal Government has little or no role in directing or shaping the development, and I say that because the private sector has itself recognized the desirability of collocation in geographic areas where there is a university complex and where there is the promise of sufficient numbers of adequately trained scientists and technicians. Indeed it has happened and it is happening.

Silicon Valley is probably the most well known. Route 128 in Boston is another. Chicago is coming along that way and this MCC or Microprocessor and Computer Cooperative, is I think the long title, is going to locate in Austin, Tex., because of the university and other companies that have located in that area.

I think that the private sector has got the imagination and the ability to figure out where it belongs. A word on the Government's involvement. The Federal Government spends about $40 billion a year on research and development, half of it in the military area and the other half in the private sector research. Those are rough numbers.

Senator HEFLIN. Well, you agree that basically industry will pick out areas and will develop them, but there are certain areas and certain activities that are going to in effect require some government grants in research and development. We have a long history.

As you said we have $40 billion in research going on today. Now there are certain things that can develop such as materials processing in space, for example, which is a very large undertaking with great potential but great risk.

Why should the fact that there is a research park prevent any of those existing or future grants in research and development? I don't understand your position on that.

You say industry will seek it out. Well, of course, they are seeking it out now, but at the same time we do carry out research and development. Isn't the fact that you do have combined efforts and you have research parks lend us a medium by which we can have faster and more efficient development?

Mr. OLMER. Well, that is a little outside of the purview of international trade and while not trying to cop out on a direct response and I would be happy to let Dr. Merrifield try to answer it. It is more in his area, but it seems to me that we are in the final analysis dependent upon the private sector for the innovation.

The private sector is dependent upon Government money and private sector talent.

Senator HEFLIN. Well, you wouldn't want to exclude universities from it would you?

Mr. OLMER. Not at all.

Senator HEFLIN. Whether a university does it in a research park or does it somewhere else, there is that element of cooperation isn't there?

Mr. **Olmer**. Oh, sure. I guess I just—maybe I misunderstood the question, Senator, but I had a vision of a bureaucrat in Washington figuring out where in the United States the research park ought to be and who ought to get how much money.

Senator **Heflin**. Well, the schools would provide it if they are going into a research park that is close to a university. The Government can in effect operate as an incentive or operate by giving grants to that area. I just think that is an area of encouragement.

Mr. **Olmer**. Sure.

Senator **Heflin**. All right. That's all.

Mr. **Olmer**. No argument on that.

Senator **Gorton**. Senator Lautenberg.

OPENING STATEMENT BY SENATOR LAUTENBERG

Senator **Lautenberg**. Thank you, Mr. Chairman.

A brief opening statement if I might. The subcommittee begins its review of proposals to build industrial growth and jobs on the base of new technologies. This is a subject of great interest to me.

I think we are talking about an umbrella of industrial policy and how research and technology fits in there. In this process we will be touching on a broad range of related issues that fall within the rubric of industrial policy. I welcome this initiative. There is a great deal to be done. We are confronted with several disturbing trends that call for some new ideas.

Unemployment is still about 10 percent. What is worse as time goes on people seem more and more willing to accept higher and higher levels of unemployment as generally acceptable.

While we continue to miss the goal of full employment, productivity until recently has also dropped. Output per man-hour grew 40 percent from 1960 to 1973 but then grew at only a 6-percent rate from 1973 to 1983.

Our balance of trade is in a deficit position and we see competing nations quickly catching up to us in terms of manufacturing growth, productivity gains and their ability to innovate and adapt. More than ever we are challenged to direct our Nation's talents and resources as efficiently as possible to put people to work, to increase productivity, to innovate, to improve our standard of living and to compete successfully in the world economy.

I think anyone who says that we don't need an industrial policy, that we've done well enough without one, is really fooling himself. We have had industrial policy at work for a long time. It manifests itself in the decision to help Chrysler and to aid specific types of education and various tax programs including writeoffs and rapid depreciation and things of that nature that all fall under my framework of industrial policy.

Unfortunately there are sometimes conflicting or confused set of policies and incentives and disincentives, subsidies, and taxes. The task at hand is to use the tools the Government has at its disposal in the most coherent and productive way to improve the competitive position of our economy, and I particularly refer to the array of tax and trade policies, patent and antitrust laws, education and training policies.

The Government has a critical role to play in regulating the proper functioning of our credit markets and in encouraging, and—we see that, of course, in the request for the Eximbank, the productive partnership between managers and workers. It also has a critical role to play in encouraging R&D in the emerging technologies because they absolutely will drive our future economic growth.

They will serve as a basis for the new service and information based industries, but they will also help revitalize our older manufacturing industries. Some of these issues I'm pleased to say have been the subject of a continuing review by a task force of which I am proud to serve along with Senator Heflin and Senator Riegle among others in our party. I am hopeful that we will produce some meaningful legislation as a result of our efforts here today.

Mr. Chairman, I would like to take a minute more just to review a couple of things that are on my mind and that we have heard here today. Secretary Olmer and I know each other from previous encounters, and I was happy to see him adopting the role of the liberal today here in describing Government's role in encouraging science education. He sees Government with a part to play.

I say this in all good humor and honestly because I think the Secretary made a very good presentation here this morning. As usual he was very comprehensive and covered lots of areas. However, I think one of the things we have to recognize is that the best R&D investment that we can make in our society is the fertilization of the mind, that is to insure that all of our young people, all of those who are trainable, have that opportunity and not be deprived of it simply because they come from a poor school district or disadvantaged home life.

I made my maiden speech the other day in specific relation to that area. While we worry about computer literacy we find another condition developing in the reverse which is computer illiteracy and we will be seeing some facts developed in the next while that confirm this concern of mine where poor urban school districts barely have contact with computer technology and some of the advanced learning techniques while the others go on in affluence not only in the school system but at home as well where the educational process has its best boost.

So I think that within the Government's responsibility there is a very serious one that will affect R&D policies and innovation and creativity for many years to come if we have the people that can provide the skills and the initiative to develop not only products for better living but for competitive business environment for our country.

Senator Heflin, I was very interested to hear your perspective on the R&D parks and it is no longer true that where they moved, and I think this is perhaps too obvious, where industry moved the jobs and the employees with skills would follow. Now, it is a whole different environment.

When we look at the Route 128's of the world, we see industries flocking there. In my former life my company has a major office on Route 128. We also have one in Palo Alto and San Jose and we also have one in Ann Arbor, Mich., near the university there because that is where the talent lives. You have got to go there to get it.

Therefore, that further confirms my view that all levels of Government have to continue to invest in the expansion of the mind. Mr. Secretary, you discussed in some terms the role of the defense spending in industrial policy. Haven't our defense efforts had significant spinoffs in civilian technology and also in developing new industry? Do you think we are paying sufficient attention to some of these spinoffs? Do we have an adequate institutional framework to encourage and to account for what has happened as a result of these investments from the defense budgets?

Mr. **OLMER**. Senator, it would be hard to say that it is adequate given the fact that we have been spending $20 billion a year with some regularity in the defense area for research and development. I think one of the significant contributions that can be made is this new effort to assure Federal contractors the ownership right to their inventions in Federal contracting. That can apply in the defense sector as well.

I really can't give you an informed view as to the adequacy or inadequacy of the monitoring process in the defense area, and I would like to defer to a later witness you have, Dr. George Keyworth, who is the White House science advisor who has made a study of the whole general framework in which our R&D activity, both defense and nondefense, is conducted.

My own senses know that it is not adequate but I do not have an answer as to how we can made it adequate.

Senator **LAUTENBERG**. What I am looking for, Mr. Secretary, is to try and figure out where we are in terms of specific industrial policy involvement and kind of discarding the cover that says that we are not interested in national industrial policy, that we think that the marketplace ought to be open, free competitive, et cetera. I support that generally, and I think you know that.

But on the other hand I think we ought to be realistic about where we are as a Nation competitively and also in terms of our employment responsibilities to our citizens and to maybe get down to the bottom line on this thing and find out that while the Government has a very significant involvement in establishing policy and in encouraging development, we ought to refine it somewhat and fess up and say OK, this is where we are at. We ought to distribute this bounty fairly.

We ought to have the kind of regional development that is required. We cannot favor one area of the country over another even though at times it is convenient to do so. We must get on with the task of a review of what constitutes really a major industrial policy.

We have it in our trade rules and regulations with which you are so familiar. We have discussed the authority for the Eximbank and the funding of the IMF and so on and these really amount to, I think, a national industrial policy in the real sense.

So the questions asked are in that framework. One of the other things I would like to just take a moment on regards the sole searching that is going on among American managers who have seen teriffic inroads by foreign competitors.

Before you mentioned the semiconductor business, and of course all of us who follow what is happening there were shocked by the operating results of Texas Instruments, which is a standout company in so many ways not only in new products but also in personnel innovation, research, and real contributors to science. To see them lose, I think, $100 million in a quarter was a shock. I don't know whether the business has gone abroad, but certainly that kind of competition is a factor.

There is, I think, some sole searching on the part of labor as well to find out how they can participate in maintaining our competitiveness. When it is recognized by the labor movement generally today that what is good for business ultimately has got to be a factor in what is good for labor, one cannot move at its own pace without consideration for the other and in making adjustments to technological change.

We have had a chance to meet with senior labor people. What do you think is the role of the Federal Government if any to promote more cooperation in this area between manager and worker and try to build a concensus so that we can set aside the combative environment that used to exist and get on with what is a requirement for all parties, namely to build a better economy, better jobs and to protect, and I use the word "protect" very loosely here, protect the lead position that we have had in both industrial and, frankly I think political as well as moral policy?

Mr. **Olmer**. Well, I guess I would note first off that in some of the areas in which we are most competitive in the world and in which we are recognized as world leaders there are no unions and there is no labor problem. I think specifically of the basic electronics industry.

Now, that is true with respect to a great deal of, in fact, I think the whole semiconductor industry and to a good deal of the computer and telecommunications industry as well. But in general management productivity needs improvement at least on the same priority level as labor productivity needs improvement. Sure there needs to be cooperation between the two.

I think that the Federal Government's role in that area is not at all clear. The first step is a recognition by both sides of the need to be cooperative and the need that their common interests are served through cooperation and until and unless that happens I do not see the Federal Government having a chance at success in instructing them in the importance of it.

Senator **Lautenberg**. We are pressed by scheduling problems for our next witness. I do not want to, however, Mr. Chairman, leave the subject without responding very quickly to Secretary Olmer's comment about nonunionization in these industries.

I do not think that is necessarily a plus for the industry. I think that is a fact of life often in new industries. It is a highly professionalized industry. There are companies as you very well know having come out of the technology business that are unionized, that are competitive especially in the hardware manufacture. I would tell you that I honestly view, and I come to this, my new life, as a professional business manager saying that I believe that there have been more mistakes made by management and I look in some of the basic industries, automobiles perhaps, that are much more devastating than the role of labor and its negotiations for a larger share of the pie.

Mr. Chairman, thank you.

Senator GORTON. Thank you. Secretary Olmer, we very much appreciate your appreciation.

[The statement follows:]

STATEMENT OF LIONEL H. OLMER, UNDER SECRETARY OF COMMERCE FOR INTERNATIONAL TRADE, DEPARTMENT OF COMMERCE

Mr. Chairman and Members of the Subcommittee, I am pleased to be here to discuss the "role of technology in promoting industrial competitiveness." This topic presents an enormous challenge and great opportunities for the long-term economic health of our nation. American jobs, our standard of living, and our stature in the world, all depend on how well we perform in this critical area. Our main trading competitors also sense that this is an important area for their national economic performance.

Shifts in relative international trade position

Following World War II, the productive capacity of the United States relative to the rest of the industrial world gave this country the ability to compete successfully in almost every market and in almost any product area. Over time, the industrial economies of Europe and Japan have rebuilt, recovered, and begun to increase their market share relative to the United States in virtually every product category and geographic market. In addition, the developing countries were building up their industrial sectors to the point where they now challenge us in a number of product areas.

While these trends cause us concern in some areas they are not all bad. We need economically strong allies to support our national security, political and foreign policy goals. Economic development in less developed countries promotes political stability, creates jobs and expands markets for U.S. exports.

However, it is clear that this constantly changing international situation provides a serious challenge to our own economic objectives. The United States is facing and will continue to face an intense competition for markets in the future, and it is imperative that we come out ahead in this struggle.

Continuing importance of manufactures in U.S. economy

Despite considerable talk about a structural shift of the U.S. economy from manufacturing to the service or information economy, the fact remains that manufactures continue to be basis of our economy and of our foreign trade. To paraphrase Mark Twain, the reports of the demise of the U.S. manufacturing base have been greatly exaggerated.

Manufacturing today represents about 23.9 percent of GNP. If we adjust for inflation, this compares with 24.5 percent in 1950. In the trade area there has been no diminution in the importance of manufactures. In 1982, manufacturers were almost 66 percent of total exports compared with 69 percent in 1963. There have been some fluctuations in the interim years, principally as a result of the ebb and flow of agricultural exports, but clearly our dependency on manufactures trade remains.

Capital goods continue to be the single largest component of exports, and of course, of manufactures. In 1970, they comprised 33.7 percent of total exports. By 1982 they had risen to 34.3 percent. By contrast agricultural goods—food, feeds and beverages—were less than 15 percent. I have included a separate statistical appendix which presents more detailed charts.

If we look at U.S. market share in world manufactures trade, it is difficult to discern a single trend. The U.S. share of manufactures is significantly lower now than in 1962, 24.6 percent versus 19.9 percent in 1982. However, the share has been rising since 1978 and is now above 1971 levels.

I urge caution in interpreting these share figures. For example, because of the lack of comprehensive world-wide statistics we must rely upon comparisons that include only the other major industrial countries. The so-called "NICs," such as Korea, Hong Kong, Taiwan and Brazil, are not included. If these countries were included, the results might look less favorable to the United States. In addition, a stronger dollar has the effect of increasing the value of U.S. exports relative to those of our competitors. This makes the U.S. share appear larger, although the volume of exports may be unchanged. Of course, the strength of the dollar relative to other currencies has also been a significant cause of declining U.S. exports.

Importance of high technology industries

High technology industries have assumed increasing importance to the U.S. trade position over the past several years. U.S. advanced technology industries have made the following contributions to U.S. economic growth and development:

A rate of growth of real output more than twice that of total U.S. industrial ouput,

A rate of inflation only one-third that of the country's overall inflation rate,

Large balance of trade surpluses,

Labor productivity growth six times faster than that of total U.S. business, and 60 percent of total private industrial R&D.

However, our focus should not be on high tech as an end itself. Advanced technology industries play a dual role. They are important industries in their own right, creating jobs and providing a trade surplus that helps offset deficits in other sectors. In addition, they make a key contribution to the competitiveness of so-called smokestack and service industries. These high tech industries provide the new processes and equipment that improve the efficiency and productivity of our manufacturing and service industries, the performance and quality of our products, and our responsiveness to changing market conditions. This is what competitiveness is all about. For example, the application of technologies such as CAD/CAM, robotics, advanced machine tools and lasers in building modular, flexible manufacturing facilities could substantially lower existing cost curves in batch manufacturing.

Our specialty steel industry is often noted to be the competitive equal of any foreign competition because the U.S. companies by and large have invested in new equipment and have applied state-of-the-art technology to their businesses. (Unfortunately, other factors have prevented most of our companies from being successful internationally; and foreign competition has been such that the ITC recently found serious injury to the domestic industry.)

High technology competitiveness

We know that the health of advanced technology industries and the size of international markets are closely related. Access to and success in world markets is a key requirement to achieve economies of scale and to spread the costs and risk of innovation over more units and to generate the cash flow necessary to produce the next generation product. Technology intensive industries need world markets to a greater extent than many other products exchanged internationally.

High technology study

The Commerce Department performed a study last year of the competitiveness of U.S. high technology industries. The examination resulted in the following conclusions:

High technology industries are vital to the U.S. economy.

National security depends upon technology intensive industries both for sophisticated items essential to modern weapons superiority, and for a strong and flexible industrial capability to meet future contingencies.

The United States will have to depend heavily on these industries to meet increased competition in world markets.

Over the past twelve years, there has been a decline in the international market position of U.S. high technology industries from a position of dominance to one of being strongly challenged. U.S. market share for the high technology group—and for nearly all individual manufacturing industries—has fallen. In 1968, our trade surplus was $6.1 billion and our share 28.9 percent. In 1981 our trade surplus increased to $30.7 billion but our share was down to 25.5 percent.

There is no question that high technology products are taking a larger share of both our imports and exports. In 1980 such products comprised 44.0 percent of manufacturers exports compared with 35.0 percent in 1965. In 1970 high tech products accounted for 19.3 percent of our imports of manufactures. In 1981 they reached 26.9 percent. This increase in the import share reflects the strong competition we face.

A number of factors influence U.S. versus foreign advances in technology that, generally speaking, apply to all industries:

the overall state of the domestic economy,

cost and supply of capital,

relative R&D efforts,

the transfer of technology,

availability of sufficient numbers of adequately trained and educated scientists and technicians, and explicit foreign industrial policies targeting the technology intensive sectors for development.

The study predicted that, if present trends continue, some or all of these factors could contribute to a further significant decline in the competitive position of U.S. high technology industries.

Secretary Baldridge decided to take these conclusions to the business community for its assessment. We sponsored meetings with leading executives of the robotics, computer, semiconductor, telecommunications and machine tool industries that were also attended by representatives from other government agencies concerned with U.S. industrial competitiveness. These informal and frank exchanges of views were most informative. Four areas of concern emerged as priority issues: antitrust laws, R&D policies, tax policies and foreign market access. I am submitting for the record a compilation of these discussions.

The innovation/process pipeline

In our effort to address these issues and devise effective policy solutions to them, it is useful to think of the process of technological innovation as a "pipeline." This highlights the fact that technological innovation is a continuous *process*, and not a discrete event.

In general, innovation can be considered to have two major stages. The first stage is the invention. The second is translating that invention into a useful commercial product or process. The large majority of the cost, the risk, and the time is associated with the second stage. It is commonly understod that in major industries, it takes 7 to 10 years to produce a significant new product or process to move through this pipeline. Perhaps one of twenty projects that starts out in the laboratory ever produces a positive cash flow. Innovation, therefore, entails high levels of risk, and if the national interest requires that the U.S. maintain world technological leadership, then it is also important to remove barriers to innovation and to provide appropriate incentives to undertake risks.

Without adequate incentives, much of the innovative, basic R&D that is done in the United States will never be translated into useful products or processes. For the "pipeline" to work properly, we need to remove barriers to collaborative effort and provide incentives that minimize risk. Also needed, of course, as I mentioned in the context of our maintaining international competitiveness, is an adequate supply of scientists and engineers; access to capital for R&D and machinery; sound management; access to critical information; and a stable economic environment that is conducive to business decisionmaking.

Our own review of this issue has led Commerce to conclude that government policies and programs can have a major influence on innovation, including the direction and rate of technical development. For example, influential factors include government procurement policies, R&D support, patent policy, antitrust, tax, education initiatives, and so forth.

Three examples of recent government actions designed to influence this process are:

The provision of about $6.6 billion of Federal funds in fiscal year 1984 for basic R&D, including an 18 percent increase in programs of the National Science Foundation, and new initiatives in the Department of Energy and NASA;

The new Commerce program which encourages private sector research and development limited partnerships—"RDLP's"; and

The Economic Recovery Tax Act (ERTA) which removed tax disincentives primarily for investment in plant and equipment.

Other policy initiatives are:

Strengthening Federal patent policy to give ownership of inventions developed under Federal contract to the contractor;

Antitrust issues—to encourage cooperative R&D through joint ventures;

The Export Trading Company Act;

The Small Business Innovation Research Program, which requires Federal agencies to expend ultimately 1¼ percent of their annual R&D budgets on innovative proposals submitted by small businesses;

Government initiatives on technical manpower issues;

Tax incentives; and

Congressional action to increase Presidential authority in trade negotiations so that reciprocal treatment can be obtained for U.S. companies.

Using this notion of the innovation process as a continuous pipeline, we can also identify weaknesses in the process. For example, while the use of R&D Limited Partnerships has provided private sector funds for the prototype or pilot plant steps, there still are insufficient incentives for venture capital to fund higher risk, *early* stage developments that may be many years away from commercial operation. A major weakness exists between the first technical demonstration in the laboratory and the prototype stage. As a result, foreign companies have found that they can acquire or license early stage development in the U.S. at very low cost, at a time when such development is undercapitalized and very vulnerable. In effect, these foreign companies are benefiting from major U.S. basic research investments at very low cost by providing development funds that are not equally available in the U.S. Therefore, we need to find ways to encourage the private sector to provide the risk capital sufficient to exploit our advanced technology.

Technology transfer

Of course, while government policy establishes a framework for innovative behavior by the private sector, the private sector has the major responsibility for managing the translation of technical advances to the marketplace. The U.S. business community should consider the trade-off between short-term gains from technology sale versus long-term costs of releasing keystone technology. While I am an advocate of the free flow of technology—the United States has gained much from such exchanges—it is instructive to observe that Japan has spent only $10 billion in royalties and fees in the past 30 years to acquire the fruits of research done mostly in the United States. (U.S. business spent roughly $280 billion on R&D in the same period.) The cost-benefits of licensing and cross-licensing agreements should be a matter of constant review by U.S. companies.

Clearly U.S. firms face strong pressures to transfer technology and the U.S. Government should oppose such pressures wherever they arise. In some cases, foreign government policies have forced the transfer of technology. One example is the French requirement for foreign firms to transfer technology in order to have access to French government telecommunications markets. Certain countries have recently proposed changes in international patent law. These changes would force multinational firms that win patents to apply them in developing nations within a short period of time.

The structure of the marketplace may make it more profitable for U.S. firms to transfer technology to foreign countries. We need to look at the factors that force innovating U.S. firms to seek the support they need from foreign firms or governments. In some cases, e.g. robotics, there is an inadequate market for the product in the United States. In the biotechnology industry, many of our small new "genetic engineering" firms rely on income generated by research contracts with large domestic and foreign corporations. A significant number of research contracts and licensing agreements have been made with Japanese companies which presently lack expertise in basic "genetic engineering" techniques, but have the know-how to apply the technology to commercialize new biotechnology products. In exchange, U.S. biotechnology firms have granted certain production and marketing rights to their foreign partners. In summary, U.S. industry ought to be thinking about the long-term consequences of this action.

Self-analysis is already underway in industry, and I am confident it will respond appropriately to the changing international economic environment.

International negotiations

Progress is being made on reducing other barriers to high technology trade. The multilateral Trade Negotiations (MTN) in some ways provided a benchmark analysis of existing traditional barriers to high technology trade, and, in many cases, reduced or lowered those barriers. We negotiated and implemented an agreement on trade in civil aircraft, and codes of conduct for several major government activities, e.g., subsidies, government procurement and standards.

Since the MTN was concluded in 1979 we have become increasingly aware that non-tariff barriers can have significant effects on trade volume, direction and mix. These non-tariff trade barriers appear to have greatest relevance for knowledge intensive industries, because of the emphasis that is currently being placed on these industries by foreign governments. For example, U.S. firms increasingly find themselves competing against foreign consortia and/or foreign governments. Foreign governments are increasingly adopting practices that "target" certain high technology sectors and provide a range of support activities.

What should we do? The answer is not easy. We need to avoid the pitfalls of protectionism. Domestic economic policies that reflect a nation's traditions and culture have not previously been the object of international trade discipline. There is considerable dispute among the industrialized trading nations regarding which kinds of practices are trade distorting and which are not.

The Administration has approached our trading partners in the OECD and the GATT, and requested that these organizations undertake a study of the issues associated with trade in high technology products. The OECD has already initiated a work program to examine these issues, and we expect that the GATT will also agree to a work program. We expect progress in these fora to be slow and agreement difficult. But we enter these negotiations with a firm conviction that open markets for high technology will maximize the benefits to be derived from this trade for all countries. Indeed, the recent Williamsburg Declaration on Economic Recovery commits the Summit participants to:

"Halt protectionism, and as recovery proceeds to reverse it by dismantling trade barriers. . . . We will give impetus to resolving current trade problems. We will actively pursue the current work programs in the General Agreement on Tariffs and Trade (GATT) and Organization for Economic Cooperation and Development, including trade in services and in high technology products."

We have also begun bilateral negotiations, primarily with Japan, but also with other countries whose policies and practices affect the international trade environment for knowledge intensive products. The United States Trade Representative has begun discussions with Japan in the U.S.-Japan Committee on Industry-Related Policies and their Effects on Trade. These discussions are a critical first step in the effort to sort out those practices that do not unfairly distort trade and are acceptable as appropriate tools of national policy, and those that are not. We have also been meeting with the Japanese in the U.S.-Japan Work Group on High Technology Industries in an effort to address specific barriers to trade and investment in high technology industries. We believe, and the industries working with us in this exercise agree, that we are beginning to make some progress.

The role of private sector management

A distinguished group of experts participating on the National Academy of Sciences' Panel on Advanced Technology Competition and the Industrialized Allies recently released a report containing the following conclusion, which I wholeheartedly support:

". . . the nation's performance in advanced technology development and trade will be determined in large part by the efforts of individual firms."

The report goes on to describe successful firms as those with "long-range vision," an understanding of the state of technology worldwide, responsive "to the international climate," and "open to developing new institutional arrangements."

The U.S. Government can assist its manufacturing industries: It can remove impediments, add incentives and provide critical information both domestically and abroad and it can improve the economic environment in which firms grow and trade. But the primary responsibility for the management decisions that will determine success or failure is squarely on the shoulders of the private sector. Private sector management in the United States is in a period of soul searching, brought on primarily by the rapid and impressive growth of market share that foreign firms have been able to gain in the U.S. market and in third markets.

Administration actions and initiatives

Mr. Chairman, and Members of the Subcommittee, as a Nation we have taken numerous actions to meet the new technological challenges:

We seem to have broken the back of inflation, and interest rates have tended to follow.

Tax incentives have been put in place, although, as I mentioned earlier, I believe they need strengthening in certain areas, for example, allowing the 25 percent incremental tax credit to be applied to start-up companies.

Members of Congress, the Administration and the private sector are working to ease the application of antitrust rules on cooperative R&D.

The President's FY 1984 budget proposes an increase of 17 percent in R&D funding, including a 10 percent increase for basic research.

The Administration has included $35 million in the FY 1984 NSF budget to fund science and math instruction at the secondary school level; in addition, the Administration is proposing an additional $50 million for higher level education and training in technical disciplines, including research awards for new Ph. D.'s.

We have strengthened Federal patent policies to give ownership of inventions developed under Federal contract to the contractor, with the expectation that this will provide the incentive for those contractors to increase the commercialization of such inventions.

Our Export Trading Company Act removes some antitrust barriers at the marketing end of the innovation pipeline.

The Department has initiated a Competitive Assessment Program, in such areas as petrochemicals, civil aircraft, telecommunications, engineering materials, machine tools and others. We also launched the Industrial Technology Partnership Program. In addition, we are actively seeking other ideas to support the technological innovation process.

In addition to public policy changes, private sector management practices must emphasize the constant search for improvements in productivity, a global strategic planning perspective for the long term, innovative labor management relations and the willingness to adopt new technologies.

In conclusion, the challenge is that of anticipating and responding to continuous change in a new world environment. The major component in meeting that challenge is rapid development, production and application of advanced technologies. This, in turn, requires: Adequate funding, incentives, and human resources; the ability to change direction and make important, and sometimes initially disruptive, management and policy decisions; and, most important, cooperation on the part of the public and private sectors towards the Nation's engine of growth.

Fortunately the U.S. is well positioned to retain and expand its technological leadership and to strengthen its international competitive position. We possess the world's most advanced technology in numerous areas, an enviable industrial infrastructure, an incomparable entrepreneurial and venture capital ability, and a large, integrated market. But, increasingly, we will need to use these resources more effectively in order to withstand the challenges from abroad now and in the future.

Thank you. I will be happy to answer any questions.

Senator GORTON. Dr. Keyworth.

STATEMENT OF HON. GEORGE KEYWORTH II, DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY

Dr. KEYWORTH. Chairman Gorton and members of the committee, for decades American industries, especially those incorporating modern technology, have dominated the world's marketplace, but now in 1983 America finds its industrial leadership and economic future challenged by aggressive, new foreign competition. As these hearings signify, the vitality of U.S. industry in world markets has emerged as a major public policy issue.

Let me offer my own perspective on how we find ourselves in this position. We Americans have always advocated competition and free enterprise as cornerstones of our society.

Throughout our history they have been the dominant forces in our remarkable economic growth. In fact, they were so successful that following World War II we found ourselves in a position to take the benefits of our economic system largely for granted.

But today we are relearning the meaning of industrial competition after letting our performance slip during those easy years. My own sense is that most people have absorbed this lesson belatedly but quickly.

Americans appear to be increasingly ready to make sacrifices and to expend the extra effort needed to improve our industrial competitiveness. We are seeing what is to me a most encouraging rethinking of issues by both management and labor as they try to improve the competitive position of the industries upon which they both depend.

Moreover, the public after years of apathy about support for education and for R&D is becoming strongly vocal. We now hear calls for higher educational standards and greater Government support for science and technology. Americans clearly understand that those activities have a direct and a necessary link to future economic growth.

Perhaps most interesting, I think the public is taking a realistic view of outright legislative attempts to shelter U.S. industries from foreign competition. They are focusing instead on assuring equitable free trade with other nations. Although this issue still hangs in the balance, the rush to protectionism that threatened to further isolate threatened American industries appears to have slowed.

Finally we are seeing better understanding for more realistic antitrust policies to permit American industries to pool R&D resources. The administration's guidelines announced earlier this month permit a greater degree of cooperation among industries and should be an important incentive for additional targeted industrial R&D.

These changes indicate to me that Americans are developing a new appreciation of competition, and I can't imagine a healthier sign for the future. It is healthy because we are improving our competitiveness by building on traditional strengths.

I often point to organizations like the Semiconductor Research Corp. or the Microelectronics and Computer Technology Corp. or other farsighted industry groups that are pooling resources to support R&D as examples of appropriately American responses to foreign competition. These industries are helping themselves rather than turning to Government to solve their problems. The Government in turn is anxious to create a climate that stimulates these and other kinds of industry initiatives.

I would like to call your attention to some recent evidence of how well the private sector understands what has to be done. The Business Higher Education Forum, a group of chief executives of major industries and academic institutions, recently completed an insightful report to the President entitled "America's Competitive Challenge—The Need for a National Response." It is a compendium of wisdom and of commonsense on this question of international competitiveness.

In a nutshell their prescription for reversing the obvious decline in America's industrial leadership recognizes that the United States can draw on enormous strengths. They singled out our capital base, our advanced technology, and our highly educated work force. Interestingly, all of these elements have come under attack in recent years but the forum realized that they remain the essential building blocks for our future.

Mr. Chairman, last March I appeared before this committee and discussed the bold steps being taken by the administration to strengthen our Nation's scientific and technical capabilities through Federal support of research and education. At that time I pointed out how the increased support for basic research, especially in universities, will generate both new knowledge and skilled technical personnel for future industrial growth.

I won't take the committee's time to go over those important points again. However, I would like to take just a few moments to discuss a critical item, the linkage between the institutions performing the Nation's basic research and the industries that incorporate and depend on new technology for their progress.

American technological progress is hindered by barriers between industry and the bulk of the basic research establishment. Most academic and Federal scientists still operate in virtual isolation from the expertise of industry.

They derive little benefit from the experience and guidance of the marketplace. One can make a convincing case that this separation is a root cause of our sluggishness at least compared to some of our more energetic competitors in turning research into products.

In the past year my office has focused considerable attention on the particular isolation of Federal laboratories. Many of those labs which were established decades ago to deal with highly specific national problems are no longer focusing on problems of first line importance, but they are still valuable resources, good people, good facilities and we intend to put them to better use.

Within the next few weeks I expect to announce the results of the White House Science Council's intensive year-long study of the Federal laboratories. The results of this project which benefited immensely from the experience and wisdom of Dave Packard who chaired the study will provide important guidance for the Federal Government in improving the effectiveness of the labs in addressing long-term national priorities.

This year we proposed a mechanism to try to develop better interaction between academic, Federal, and industrial scientists, and that was the new National Center for Advanced Materials at Lawrence Berkeley Laboratory. As you know some people in the materials research community have pointed out that there are other research institutions better known for work in materials science and they ask why should this center be established at Berkeley.

That is a fair question, but it misses an important, indeed, a central point. We're concerned with the broad impact on American science and technology of this center, not solely with its impact on the discipline of materials research.

NCAM is intended as a mechanism to show us how to better couple our Federal labs to current national needs, and LBL is uniquely suited, a Federal laboratory located on an outstanding university campus and in a region noted for innovative industry.

Perhaps we didn't make the point clearly enough but let me emphasize that we have always seen NCAM as more than just a materials research center. It is a test bed for mixing different research viewpoints, focusing research better and speeding up the transfer of new knowledge to the market place.

In light of the pressing national need to do just that, we have been disappointed at the reception for NCAM in the materials research community. For the past 2 years the administration has made this kind of linkage a prominent objective of its science policy, yet in recent weeks we have seen the modest start-up funds for this important new effort almost casually traded in the House of Representatives for hastily introduced projects to construct new buildings at two other universities.

Even more distressing, those two projects backed up by a professional lobbying effort were introduced abruptly on the floor of the House and completely bypassed any semblance of review by the science community. I am distressed to see the introduction of this self-serving, pork-barrel mechanism for allocating Federal funds for science, and I worry about the precedents that this could establish.

Even now we're seeing another attempt to inject nonscientific criteria in a decision about a new research tool, and that is the Department of Energy's new National Electron Accelerator Laboratory, a critical facility for the future of American nuclear physics. A blue ribbon scientific panel reviewing proposals from a handful of organizations concluded that the proposal from the Southeastern University's Research Association clearly offered the greatest potential scientific returns to the Nation.

But now we see attempts by a losing bidder to have that recommendation bypassed for what I would call institutional reasons. That is, the belief that an ailing Federal laboratory is entitled to the new project because it's threatened with loss of jobs unless it can come up with new programs.

So here we have a situation in which we encouraged competition among bidders and now are being asked to reward the losers—who now want to appropriate the winner's project design for their own. I don't know what rubric that goes under today, but it used to be called claim-jumping.

I ask you—is this the way we're going to use Federal resources to their best advantage to stimulate the creativity and innovations that will increase competitiveness? Of course not. That would be exactly the wrong message for the Federal Government to send out to the science and industrial communities.

One thing is certain. Creativity and innovation are not likely to come from Washington. I freely admit that I can't and I won't tell a place like Oak Ridge National Lab or MIT or General Motors how to develop cooperative programs or how to link public and private sector interest. But the Federal Government should create a climate to encourage those things, and it can make a commitment to maintaining that climate.

Mr. Chairman, I believe the administration is taking a sensible approach to industrial policy, carefully defining the appropriate Federal role, building on our strengths, and avoiding the twin pitfalls of intervention in industrial planning and tampering with the competitive forces in the market place. I realize I've touched only briefly on many topics, and I would be pleased to discuss any of them further.

Thank you.

Senator GORTON. Dr. Keyworth, to what extent has your office or any other agency of the administration, to your knowledge, undertaken a comparative assessment of American and foreign manufacturing technologies, particularly in any fields in which we seem to be lacking?

Dr. KEYWORTH. Senator, for all of us involved in government in trying to answer this question, the speed with which technology is progressing makes it very difficult to take a snap shot. But we, the Department of Commerce, the Department of Defense, and others have been trying to interact with as many American industries, especially those dependent upon technology, as we possibly could to answer exactly that question. As Under Secretary Olmer said, we have received input from a lot of industries that clearly indicates an inability to rapidly move our new knowledge into the marketplace, and, something that you have emphasized, Mr. Chairman, our inability to incorporate new technology into our manufacturing processes. These are real problems, and the question is how we deal with them and how we establish priorities.

Senator GORTON. Let's go to NCAM. You expressed some disappointment in its development and use. To what extent is industry interested in NCAM? To what extent do you think that it is a model that can be applied in other areas, and what have you learned by your disappointments in it so far?

Dr. KEYWORTH. First, in evaluating this project, from the very beginning we quietly discussed the interests of quite a few industries from petrochemicals to semiconductors to advanced materials, aircraft, et cetra, and received enthusiastic support. Maybe more importantly, the Department of Energy has established in the last few months a committee composed of members of the materials science community and represented very heavily by industry to assist in careful planning.

Now the word "model" is one that I have myself used many times with respect to NCAM, and I would only emphasize that there are many different models. This is an experiment. I am confident that we will learn a lot from this experiment.

I think that one of the driving motives is the uniqueness of a major Federal facility on a major academic campus, as I emphasized in my testimony. It will be an evolutionary process as to how to let the expertise in academia directly influence industry, how to let the expertise in industry and the proximity to the market place influence leadership of the institution.

The exact mechanisms must be worked out, and I think this is an environment in which that will be very successful. What have I learned about it? I have learned among other things something I should have learned before, that the scientific community is no less interested in pork and no less self-serving than any other community in the country.

Senator GORTON. In your testimony you stated, and I quote, "American technological progress is hindered by barriers between industry and the bulk of the basic research establishment." You, of course, want to establish better ties.

Could you give a little bit of insight as to how you are going to attempt to build that bridge?

Dr. KEYWORTH. Again, I think many mechanisms, those improving communication and sharing of interest, have got to be promoted. You will notice certainly, Mr. Chairman, that we have introduced quite a number of programs in the National Science Foundation and elsewhere that involve sharing.

Frequently in these programs the Federal Government carries the overwhelming majority of support and responsibility. That is not the entire point. The point is to get the active involvement of industrial leaders.

I think one of the most encouraging things that I have seen in my brief tenure in Washington has been the revitalization of, the resurgence of interest by, American industrial leadership towards being innovative and imaginative and towards drawing upon American industries, cooperative programs, shared ventures, and involvement of industrial leaders in the management and priority setting of our major Federal research centers. I am encouraged even in the ways we support universities, for example at RPI, which I find to be an absolutely excellent example of a university changing direction in just the last few years in response to competition. So I believe we are all going to have to pay a lot of attention, and we will have to be imaginative. Different mechanisms will develop in different parts of the country around different universities.

Senator **Gorton**. Dr. Keyworth, I have a number of other questions and followups, but I think because of your schedule and because I want Senator Heflin to be able to ask questions we will submit those to you in writing.

Senator **Gorton**. Senator Heflin.

Senator **Heflin**. You have talked about the report prepared by the Business and Higher Education Forum. I think it is a very valuable contribution. I am sorry that through a schedule problem we missed having a witness from that group and hopefully we can have a witness later.

The forum study had some specific recommendations in its report. For example, they talk about a Presidential adviser on economic competitiveness and a national commission on industrial competitiveness.

They also make proposals in the area of trade, capital investment, innovation, and human resources. What do you think of these recommendations, and will the administration be implementing any of them?

Dr. **Keyworth**. Yes. Senator, I think the priorities are very much in consonance with our own administration's interests and the President's in particular. The Commission is thinking along virtually identical lines with regard to the President's Commission on Industrial Competitiveness, whose composition will be announced in the very near future and is something we have spent time developing.

As far as an adviser to the President, I believe the particular mechanism that the President would choose is, of course, one best suited to his own style and method of operating, but I think at the time the forum came up with that they were unaware of the fact that an enormous number of Cabinet councils last fall addressed just this issue. It has been one of the President's top priorities, and a number of his advisers have necessarily taken that as a very high agenda item for themselves.

The basic tone and recommendations of the forum are entirely consonant with the President's own views, and many of these specific recommendations addressing capital formation, trade, et cetera, are things that we are trying to wrestle with and trying to find crisp solutions for, just as you are.

Senator **Heflin**. Well, we always appreciate having you. You always answer things with candor, and I wish we had more time. There are a lot of things I want to go into, but I will delay that until a later date.

Thank you.

Senator **Gorton**. Thank you very much, Dr. Keyworth. We appreciate your being with us.

Dr. **Keyworth**. Thank you.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR GORTON AND ANSWERS THERETO

Is there a shortage in engineers and other technical personnel in the manufacturing industries, as distinguished from a shortage of Ph.D. research engineers?

Answer. Indicators suggest that at the moment there is a reasonable balance between supply and demand for engineers, with some newly graduating engineers having trouble finding good jobs. The Deutsch, Shea and Evans high technology recruitment index of technical manpower demand has been below 100, a level arbitrarily set in 1961 and indicative of full employment, for almost a year. Starting salary offers to engineering graduates have leveled off somewhat, also indicating a generally abundant supply of applicants.

Two comprehensive studies of engineering manpower projections have been published in the past year. One, by the Business Higher Education Forum entitled "Engineering Manpower and Education" concludes that while the existing engineering manpower system "has a great deal of built-in elasticity," by 1990 there is likely to be an excess of demand over supply for new engineering graduates. It does not distinguish among fields. The National Science Foundation, however, using similar data and four different economic growth scenarios, finds that by 1987 demand is likely to exceed supply in two fields only: aeronautical engineers and computer specialists.

The NSF study emphasizes the various ways in which industry can (and usually does) meet its needs for technical manpower, as job opportunities and wage incentives draw workers from related fields. These substitutions are usually not included in manpower supply and demand projections.

Our own assessment is that temporary shortages of specific technical skills are likely to occur in specific geographic areas over the next decade. As the problems with engineering education which we have identified in the past two years are addressed by universities, state governments and industry, the technical manpower system will generally be able to continue to respond effectively to industrial demand, however.

Question. What is the appropriate role for the Federal government in addressing the short supply of technical personnel?

Answer. Technical manpower availability is of concern to the Federal government primarily for two reasons. The first is to maintain the resurgence of our international industrial competitiveness. The other reason is to ensure qualified personnel for national security within DOD, in other Federal laboratories, and on the staffs of defense contractors.

The Federal government has the responsibility to monitor how well the overall education system meets critical and continuing national manpower needs. In a world where technology continues to evolve rapidly and where the "half life" of a newly graduated engineer is estimated to be about ten years, it is essential that we maintain the flexibility of our manpower supply system. Given the four years it takes to graduate an engineer, the several years it takes to gather data on trends, and the year or more to agree on what the trends are, a centralized, Federally controlled technical manpower supply program would be hopelessly incapable of orchestrating the supply of industry's technical manpower needs. Instead, we are encouraging a variety of programs and activities which will support actions by universities, industry and state governments, for example, to hire and retain high quality faculty; upgrade teaching facilities and laboratories; experiment with continuing education programs, often offered off campus at the work place; and to stimulate university-industry interactions.

Question. How would you suggest such a climate [to encourage the development of cooperative programs linking public and private interests for innovation] should be created and maintained?

Answer. Economists are agreed that the most important factor by far in stimulating industrial innovation is the general economic climate.

In that context, the government's primary role is to ensure that its support for R&D and innovation is widely perceived and continuously reinforced. Some of the more important elements of such a program include: a clear articulation of the government's science policy and the complementary responsibilities of the government and industry in supporting R&D; its strong support for those activities which fall within its own purview; ensuring that legislation or government policies on behalf of assorted national goals do not unnecessarily hinder or discourage industry's ability to invest in R&D or to reap the rewards for so doing; stimulating a variety of mechanisms to facilitate greater industry-university interaction; and providing a clear rationale for its policies and programs that will ensure their long term vitality and support.

Question. What are the essential components for encouraging the development of cooperative programs?

Answer. The most effective mechanism for technology transfer is people transfer. Hence any successful cooperative program must encourage and facilitate the two-way flow of good scientists and engineers between the various participating organizations. This can be done by the physical location of the cooperative venture, by removing Federal government imposed barriers to the exchange of staff (e.g. waiver of invention rights), but most of all by changing the institutional reward structures so that it is in everyone's best interest to cooperate, e.g., by making unique research equipment available to the cooperating parties.

Senator GORTON. We will call our next two witnesses up together, Bernard O'Keefe, chairman of the National Association of Manufacturers and Dr. Jack Albertine of the American Business Conference. If you would come forward.

We thank both of you for coming and for your patience this morning so far. Mr. O'Keefe, you may proceed.

STATEMENT OF BERNARD O'KEEFE, CHAIRMAN, NATIONAL ASSOCIATION OF MANUFACTURERS

Mr. O'KEEFE. Thank you, Mr. Chairman. I do have submitted testimony for the record.

Senator GORTON. That will be included in the record.

Mr. O'KEEFE. Thank you. That testimony includes all of the usual industrial rhetoric so I think I would rather go to some points fairly directly which have some combination of my personal philosophy and the policies of the National Association of Manufacturers.

I would like to hit on the question of industrial policy. There is certainly an industrial policy in this country. About 30 percent of our exports and imports are protected by nontariff barriers.

Our industrial competitors or partners, depending upon whether we are buying or selling, have all had industrial policies from day one. The United States has carried on the concept of a free market. This concept was brought about in the 1950's and 1960's when the United States was the market leader in the world. Now, in industrial planning, market leaders are always for a free market. They don't want any constraints on their ability to compete, and they can be very sanctimonious about it which is what the United States has been.

However, countries like Japan and Germany, and I think I will concentrate on Japan because there is more data on it, have recognized, even from the early days of the MacArthur administration, that they were a No. 2, 3, or 4 competitor. They simply had to have some protection so they have been working in protectionist economies since 1945. Although we in the United States would like to retain as much of their free market as we can, I firmly believe that the free market emperor has no clothes and if we're going to compete with these people we have to recognize that if they're not going to play by our rules we have to change our rules a little bit.

Now with respect to industrial policy which all of this leads to, I think it is a little early to try to formulate a specific industrial policy along the lines of people like Thurow but rather for the near term to (a) do some studies on it; and (b) to stop shooting ourselves in the foot in areas where we, by our own doing, are less than internationally competitive. I am pleased to see that the two administration members earlier had cooperative R&D on the top of their list, because regarding cooperative research and development under the antitrust laws, the first feeling of the administration, I believe, was this could be handled administratively.

Of course, you go down to the Justice Department and they say, "Hey, there are no rules against cooperative R&D." You can go ahead and do it, and those of you in the Senate who are attorneys recognize that what happens when we go back to our general counsel he says don't believe those guys for a minute. The attorney generals will come and the attorney generals will go and you keep your nose out of it until they do something about it so that I believe I hear the administration saying that they are moving toward specific legislation.

I urge you—there are a number of bills some introduced by the Senator from Massachussetts, Senator Tsongas, but I do believe that we need specific legislation and that people like Control Data who are doing a good job and taking a chance I have got enough media backup that they will make it but others will not.

Another aspect that I would touch on for a minute is the question of technology transfer, and I believe I have a little specific experience in this. The United States and Japan put out about as much per capita in research and development, about an equal amount roughly speaking.

However, all of theirs goes to commercial and more than half of ours goes to defense. Now, when I'm not chairman of the National Association of Manufacturers I am chairman of the EG&G, a Route 128 so-called high-technology company of which I am a founder. We now do $1 billion worth of business in many States and many countries.

But part of our business we do operate laboratories. We operate the Idaho National Engineering Laboratory. We operate the base operations for the Kennedy Space Center of which we have had two perfect launches since we took over, and we also operate a highly commercial business.

One of the problems that we have is, in fact, a transfer with the results of R&D from the defense-oriented establishment to the commercial, and there are two kinds of reasons for this. One is the nature of the researcher who in one case is more interested in the advancement of science, and in the other case is more interested in bringing some product out to the good of the community.

These are both excellent philosophies but they are, in fact, different. The second is something that can be, I think, handled in the Government and that is the reluctance of an administrator of government contracts quite naturally to give what might be conceived as preferential treatment to particular industries. Both of these are understandable, but both of them have to be attacked in a certain case.

The third thing I want to mention is the fact that there are many things that we have to do other than R&D that would improve our competitive advantage. The uncompetitive dollar is certainly a major factor.

I have been testifying for myself and for the NAM on the Export Administration Act in which in one case we looked for industrial competitiveness and in another case by grain embargos, pipeline fiascos we prevent ourselves from utilizing that advantage. So now in looking at the bills which I understand are going to be considered, 428 and 632 are two of them, both of which provide for studies.

I think ad hoc committees are a good thing. They should consider these things first. With respect to 1286, I am very much in favor of the concept of 1286 in that as I go around the country as a founder of a high technology company everybody wants to be in high technology whether you are in Mississippi, Minnesota, Chicago, or what have you.

I submit that everybody can't be a microchip maker. We happen to be microchip makers in Silicon Valley and everybody can't make monoclonal antibodies from biochemistry. For everyone to go after the ultimate of high technology is in fact the wrong thing.

I believe we will be much better served if we can devote our research and development to the improvement of those manufacturing techniques and capabilities which already exist in these areas. For example, the Chicago area is a metal working, metal bending area. You don't want to make computer programers out of them. We should do research in metallurgy, in welding, in areas which will utilize the work force that exists and the capabilities that exist with them.

With that I think I will stop this little ramble and open myself up for questions or Dr. Albertine, whatever your schedule calls for.

[The statement follows:]

STATEMENT OF BERNARD J. O'KEEFE, CHAIRMAN, NATIONAL ASSOCIATION OF MANUFACTURERS

I am Bernard J. O'Keefe, Chairman of the Board of EG&G, Inc., Wellesley, Massachusetts and Chairman of the National Association of Manufacturers. The NAM is a voluntary membership organization representing over 13,000 companies which employ a majority of the country's industrial labor force and which produce more than 85 percent of the nation's manufactured goods. The NAM is associated with an additional 158,000 businesses through the National Industrial Council and NAM's Associations Department.

We commend the Committee for holding these hearings on S. 428, the Economically Strategic Industrial Research and Development Act; on S. 632, the Frontier Technologies Assessment Act; and on S. 1286, the Manufacturing Sciences and Technology Research and Development Act.

I would like to applaud your concern for the state of manufacturing in the United States today, and your commitment to consider the issues revolving around technology and policy. NAM supports efforts to provide incentives and remove disincentives to technology development and utilization in order to improve the ability of United States firms to compete in an increasingly technological global market.

NAM enthusiastically supports the concept of performing competitive assessments on sectors of our economy on a continuing basis to identify ways in which public policies may be revised in order to adapt to rapidly changing technologies. However, the design of "technology development programs" and examination of "market prospects" and "commercial viability" as provided for in S. 428 and S. 632 are more properly left to the private sector. NAM also supports government activities which promote "more efficient manufacturing processes and methods and to encourage research utilization." However, the programs outlined in S. 1286 need considerable refinement before they will be effective. Some comments on these bills follow my brief statement, and the NAM looks forward to working closely with your staff in fashioning legislation that NAM can support.

As the findings in S. 428, S. 632 and S. 1286 indicate, two distinct trends have emerged over the decade of the '70s and into the '80s. First, the caliber and intensity of foreign competition have grown dramatically, most notably from Japan and West Germany. Secondly, the United States' capability for applying technical advance to industrial and economic activity, i.e., the process of industrial innovation, has been called into question.

Attention has turned to "high-technology" as a way of solving our industrial and economic difficulties. High-technology comes from the achievements of "state-of-the-art" high-technology firms in a group of exciting technologies.

These firms create products and processes for the bulk for the economy. The relationship is symbiotic: basic industries provide a market for these products and processes, and high-technology industries contribute new and improved ways of increasing output. The application of these achievements can have a major impact on the day-to-day operations of even the most mundane manufacturing operations.

Policies which provide a stable environment that encourages technological advance, and the integration of technological advance into existing patterns of social and economic activity are of clear benefit to our whole economy. Unfortunately, policy measures which facilitate the development of innovative capacity often cut across traditional lines of jurisdiction and authority in the federal government. The resultant confusion distorts the efficient workings of the free market. An example often cited is export controls for high-technology goods. On the one hand the federal government seeks to develop industrial capacity and promote a strong U.S. presence in global markets in high technoloy fields—yet the export of these goods and services is often the first thing to be limited for foreign policy reasons. The result: a perception abroad of the U.S. as an unreliable trading partner.

The legislation being discussed today represents but one small part of a large body of policy that impacts upon the technological competitiveness of American industry. Policies which establish disincentives through uncertainty or direct impact must be revised. For example, we must improve the education function in our society at all levels, and particularly in math and the sciences. We must ensure that the protection accorded new technologies by our patent system is not eroded. We must provide for stable export policies that promote, not restrict, international trade. We must create a tax code that encourages research and development, and it's commercialization. We must promote cooperative research and development ventures. And finally, we must encourage greater industry-university cooperation.

With these points in mind, let me make some comments about the legislation, particularly S. 1286.

The fact that this Committee is devoting time, effort and attention to technology policy issues and recognizes the significance of innovation policy to our economy is extremely encouraging. An unused idea does not benefit anyone.

The competitiveness studies provided for in S. 428, S. 632 and in S. 1286 are extremely important. However, given the fact that technology will continue to be a central characteristic of our economy, an *ad hoc* panel may not provide a comprehensive focal point for technology and innovation policy issues. There should be a continuing high-level concern in the federal government. The Department of Commerce could provide this sorely-needed coordinating function by assessing the competitive impacts of public policies affecting technology and innovation.

The centers may be duplicative of existing programs. P.L. 96-480, the Stevenson-Wydler Technology Innovation Act, already provides the Department of Commerce with the statutory authority to undertake this activity; the National Science Foundation has a similar program; and the Department of Defense's "Mantech" program also funds research in topical areas. Care should be taken to ensure that S. 1286-type programs are complementary with existing programs.

The funding levels in S. 1286 are wholly inadequate to achieve significant change in manufacturing processes or technologies.

To the extent that there is a technology problem in manufacturing processes and methods, it exists toward the more basic (or generic) end of the research spectrum. Industry underinvestment in research and development aimed at exploration of basic properties and processes can occur because the results are public goods—potential returns on these investments will often not be captured by any single firm. The grants mechanism will focus efforts in this area more effectively.

The involvement of industry needs further thought and refinement. For efforts involving industry funding (to "expand the scope of research" in centers or in cooperative agreements) patent and licensing arrangements must be specified. Is it intended to have generic research patented? If not, who will get the results of research performed? Will patent rights on research results be vested according to Public Law 96-517 and the Presidential memorandum of February, 1983? Who will receive any profits generated through licensing?

Has any consideration been given to the antitrust implications of industry involvement? A review and comment from the Department of Justice would be appropriate.

In the selection process of projects for the centers and for cooperative agreements, the recommendations of the Advisory Committee should be given more weight. The history of government involvement in "targeting" research in commercial areas has been poor.

The positive spinoffs for university research and education will be significant. But to achieve maximum benefits for federal funds expended, extensive provision should be made for transfer of research results. Care must be taken not to simply recreate the insulated structure and problems of the national lab system, where dissemination of useful knowledge takes place in only a relatively small percentage of cases.

The centers will have a difficult enough time accomplishing their primary purpose of research without charging them with formulating strategies for "retraining workers who have been displaced from declining industries." Surely this type of activity is beyond the scope of the centers--if not even the Department of Commerce. Removing this portion of the legislation might also obviate the need for labor involvement on the Advisory Group.

Senator GORTON. We will hear from Dr. Albertine first.

STATEMENT OF DR. JOHN M. ALBERTINE, PRESIDENT, AMERICAN BUSINESS CONFERENCE

Dr. ALBERTINE. Thank you, Mr. Chairman, for inviting me to testify and the American Business Conference to testify this morning. I would like to submit my written testimony for the record and would simply like to make three or four or five points that I think are important.

Senator GORTON. It will be included in the record in full.

Dr. ALBERTINE. First, let me say my name is Jack Albertine. I am President of the American Business Conference, and the American Business Conference is a relatively new organization. It is an organization composed of the chief executive officers of 100 mid-size high-growth companies. We define mid-size as $25 million to $1 billion in annual sales, and we define high growth as at least 15 percent compounded annually for the last 5 years; so every member of the American Business Conference has at least doubled in size in the last 5 years. And we are very proud of the fact that the President announced the creation of the Commission on National Industrial Competitiveness at an ABC company, Millipore, in Massachusetts on January 26, 1983. We are just simply wondering why it has taken from January 26, 1983 to the present time to firm up the commission.

With respect to the issue we are discussing today, Mr. Chairman, it is our view that the critical, most critical underlying economic problem this country faces is its productivity performance. We get terribly confused sometimes when we think about economics. If we have a zero rate of growth of productivity with a zero rate of growth of inflation, for example, the standard of living of the average American will decline. If we have a 3-percent increase in the rate of growth of productivity and a 50-percent inflation rate, the standard of living of the average American will rise.

Now, controlling inflation is a very important economic issue, but the most important question is, How do we make sure that our productivity grows? The growth of productivity affects the standard of living of the average American, and it directly affects our international competitiveness.

So we as an organization try to focus in on the question of what is really happening in the economy in terms of our productive capability. And if you examine all of the work done by business people, by scholars, both economists and noneconomists, you will probably find that the major variable which affects the rate of growth of productivity in this economy is the capital-labor ratio. The second factor is the quality of the capital stock, which is what this subcommittee is concerned about, technological change.

What has happened in this country, frankly, Mr. Chairman, is that since 1965 we have experienced deterioration in the rate of growth of productivity, and we have also, as a causal factor, experienced deterioration in the capital-labor ratio. And it is our view that this deterioration is at the heart of the failure of our economy to produce gains in productivity and is at the heart of our problems with respect to international competitiveness.

Now, there are some scholars who say that the reason the capital-labor ratio has declined in this country is that the configuration of output that we are producing is changing. They say we are moving from a capital-intensive society to a high thought content, high value added intensive society, and that this is a natural phenomenon. They claim it follows the laws of comparative advantage, and we ought not to fight it.

Our view is that the reason the configuration of output has been changing is that our capital intensive sector, in fact, has been essentially noncompetitive with our international competition, because of Federal policies and because of other factors.

Recently, the American Business Conference, along with Dr. George Hatsopolous, who is chairman of the board of the Thermo Electron Corp. in Massachusetts, completed a study on the cost of capital in the United States and Japan, I would like to submit for the record, if I could, Mr. Chairman, a summary of that study which appeared in the April 30 edition of The Economist.

Senator **GORTON**. That will be included in the record.

Dr. **ALBERTINE**. What we found, Mr. Chairman, is the cost of capital in the United States is about three times as high as the cost of capital is in Japan.

Now, what we conclude from that is that the U.S. capital-labor ratio relative to the capital-labor ratio in Japan has to decline, because the cost of capital is much higher here than it is in Japan. We think that the high cost of capital has been the driving force behind the deterioration of our capital intensive sector.

Looking at our numbers, for example, if we were to lower the cost of capital in the United States by one-half, our numbers show that the steel industry would have an additional $3 billion a year to invest in steel capacity.

Now, it is our view that not all steel companies would be able to succeed, but an additional $3 billion worth of investment and an additional $3 billion worth of R&D, as Mr. O'Keefe has indicated, would be a major factor in revitalizing the steel industry in America.

Mr. Chairman, what our study also shows is that the high technology sector in this country today is about where the capital intensive sector was in 1960; that is, we are about to get wiped out by the Japanese as well as by our other trading partners.

We did a couple of elementary calculations, and they show that, given the relative cost of capital in the United States and Japan, a project which has a 10-year time horizon requires a probability of success five times larger in the United States than in Japan in order for it to be rationally undertaken here.

Now, you can quarrel with five times. Maybe it is 4.5 to 1, maybe it is 4 to 1, maybe it is 3 to 1. But regardless of what the exact numbers are, the fact of the matter is that given those numbers, our high technology sector in this economy cannot in our view remain competitive with the Japanese.

Now, with respect to the specific issue that this subcommittee is addressing, we agree with the National Association of Manufacturers and Mr. O'Keefe that we obviously do have an industrial policy in this country at the moment. It is an industrial policy which is basically irrational. It is basically, in our judgment, responsible for a massive misallocation of resources and has contributed to the decline in our international competitiveness.

We would not like to see an industrial policy which worsens the problem by setting up a massive program to allocate resources out of the Federal Treasury, nor do we want to see the Federal Government involved in the process of trying to pick winners. We think that the market system does that pretty well now. But our view is that we ought to have an industrial policy which decides that the Federal Government has a role in systematically removing roadblocks to economic growth which now exist as a result of prior Federal policy. We rather think that your bill, Mr. Chairman, 1286, fits very nicely within the concept that we have with respect to industrial policy, namely, that the Federal Government does have a role in stimulating various sectors of the economy that are terribly important with respect to building our basic infrastructure.

So we are supportive of that kind of industrial policy which tries to provide the climate within which the private sector can create jobs and expand.

And let me make just one or two other comments relative to the comments that Mr. O'Keefe made. I would personally be cautious with respect to a couple of issues that have been raised here today. One is this question of currencies.

It is fashionable for many people to suggest that somehow the high foreign currency price of the dollar relative to the yen, for example, is a function of manipulation on the part of the Japanese. That may be the case, but I would urge this subcommittee to be very cautious before it accepts that view.

The high yen price of the dollar can be explained by some fundamental imbalances in the American economy due to the trillion to a trillion and a half in deficits projects for the next 5 years. That has had the effect, in our view, of keeping relative rates of interest higher than in the countries of our trading partners, and that has caused some of the strength of the dollar.

Second, if the Japanese are manipulating the price of the yen—and they may be—it is still important to remember that you cannot peg the price of your currency without losing control of your currency. You cannot have it both ways.

If the Japanese are forcing down the price of the yen arbitrarily, that must mean that they are printing yen, which at some point is a dangerous policy in terms of their own problem of future inflation rates.

And third, I think it is clear that the United States continues to be the absolute best market in the world. We are the most politically stable country in the world, and that is a factor with respect to the high price of the dollar.

So before we would rush to judgment on the question of the Japanese manipulating currencies, I think we should look at what would happen to the dollar if we put our own financial house in order. That would ease some of the pressure on the dollar and is the route, in our judgment, we ought to take.

Thank you, Mr. Chairman.

[The statement follows:]

STATEMENT OF DR. JOHN M. ALBERTINE, PRESIDENT OF THE AMERICAN BUSINESS CONFERENCE

Good morning!

I am pleased that you have invited me here today to testify on the critical issue of technology and industrial competitiveness. I am the President of the American Business Conference. The ABC is a coalition of nearly 100 Chief Executive Officers of mid-sized companies that have more than doubled in size in the last five years. These firms have grown so rapidly because they are super competitive.

While there are ABC firms in almost every subsector of American commerce, a significant subset of our members operate in what some have labelled the "High Tech" sector. From my discussions with these CEO's I have gained valuable insights on the interrelationship between technological progress and growth in the American economy.

I think that technological progress and capital accumulation represent the keys to solving the fundamental economic riddle of the last decade: poor productivity performance. Only an improvement in productivity performance can raise the standard of living in this country. Even if we reduce inflation to zero, our standard of living will decline if productivity growth remains in the doldrums.

Studies have shown that the major determinant of productivity is the amount and the quality of capital available for each worker to use. Technological advances raise the quality of capital stock, increase productivity, and elevate our standard of living. Larger and more rapid gains in technology imply larger and more rapid gains in our standard of living.

One of the reasons why the members of the American Business Conference have been so successful is that they are always among the first in their industries to adopt the latest equipment and manufacturing techniques. Their productivity is extraordinarily high. They invariably have the most advanced and sophisticated capital stock in their industries, and this is one of the factors that has made the ABC companies the winners of the American free enterprise system.

Certainly, the importance of technology to our economic vitality is not news to today's policymakers. Many studies, following the pioneering work of Edward F. Denison, have attributed between one-third and one-half of the increase in our standard of living in the twentieth century to technological advancement. There is no doubt that America's position as the world leader in technology and innovation led to our position as the economic leader of the free world.

In the last two decades, we have seen the importance of high tech exports grow relative to our other export commodities. Since the 1960's, the U.S. balance of trade has been better in high tech products than in all other product categories.

Yet, we are already experiencing significant erosion of our markets in an increasing number of high tech products. Some of this erosion can be attributed to the collaboration of foreign governments and foreign industry to gain a technological edge in critical and/or lucrative commodities. Many Americans have called for an intensive government program to rebuild our sagging industries and coddle our infant industries. They claim that we need an interventionist industrial policy to ensure that our economy remains competitive.

I think that our government should do everything it can to stimulate innovation and technological progress within the context of a free market economy. However, we do not need government agencies to "pick the winners". The free market system in this country and our venture capital market already do this with great efficiency. The last thing we should do is begin the evolution of a centrally planned U.S. economy.

That's what we don't need to do. What the government can do is initiate collaboration among government experts, academicians and industry representatives to discuss ways in which government and industry could facilitate technological advances in critical subsectors of the economy. Modest government grants to expedite this process would certainly be helpful. Perhaps, a reevaluation of how our antitrust laws inhibit joint ventures for research and development is in order.

I support S. 1286 because it is a thoughtful approach to a very complex economic problem. Moreover, it allows the free market forces to make the final decisions about economic success or failure. It offers seed money, not a bailout. The Centers for Manufacturing Research and Technology Utilization that it would help create would not only support applied research but help disseminate the results of this research to American manufacturers.

S. 1286 would also authorize an experimental program to retrain displaced workers and give them the most up to date skills. I think that the problem of displaced workers—workers with the wrong skills for today's economy—is not going to disappear. In fact, it will probably grow much worse. And, I think that an experimental program would give policymakers insights on how to handle this complex problem before you are forced to consider spending billions of dollars.

However, the major reason why I support S. 1286, is that it would send a signal to U.S. industry that this government is committed to encouraging economic growth and speeding innovation. It would also send this same message to our foreign competitors: the U.S. government is going to send its varsity team to play the international competitiveness game.

In closing, I would also like to suggest that this subcommittee explore several other means of accelerating the pace of applied research in this country. Many of the members of the American Business Conference, particularly those in high tech companies, complain to me about the lack of qualified engineers and scientists. The engineer shortage is so intense that few engineers go on to graduate work. Instead, they go right out into industry to earn a hefty salary. This means that there are fewer super-engineers doing advanced research in our universities and also that there are fewer professors to teach undergraduate engineers. Perhaps you should consider establishing scholarships and grants to promote graduate and undergraduate study in engineering and the sciences. This would be one quick and relatively simple mechnanism that would go hand in hand with the spirit of S. 1286.

Thank you.

The Economist

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BUSINESS BRIEF

America cannot afford its cost of capital

American businessmen have long complained that raising money is too expensive. Their arguments usually allude to real rates of interest which—taking triple A corporate bond yields minus the rate of inflation—are about 7%. In fact the real cost of capital is much higher. This week, Mr George Hatsopoulos, chairman of a Massachusetts high-tech company and a director of the Federal Reserve Bank of Boston, told the joint economic committee of congress that the real annual cost is close on 20% and has been at this level since 1974.

Backed by detailed research* from a team of businessmen, engineers and economists (including some from the Massachusetts Institute of Technology) Mr Hatsopoulos argued that this high real cost of capital (three times the level in Japan) is American industry's biggest handicap. It is smothering economic growth and innovation, and lies behind growing import penetration (especially from Japan).

Estimating the cost of capital is more complex than the stripping of inflation from bond yields. Capital costs depend both on where the capital comes from (debt or equity) and where it is going to (fixed assets, inventories or receivables). These different uses of capital have different tax allowances, depreciation rates, etc, which affect the overall cost. Chart 1 shows where non-farm, non-financial American companies have raised money since 1960, and what they have done with it.

The overall real cost of business investment has two ingredients:

- The basic cost of raising money—a weighted average of the cost of debt and the cost of equity. For the marginal cost of investment (the cost of one extra unit) the appropriate weighting is a company's target debt-equity ratio. This, says Mr Hatsopoulos, for the average American company, is 1:3.
- The costs and benefits arising from the different ways the money is used: depreciation, tax rates, investment allowances, inflation rates, and inventory obsolescence.

The overall cost of capital is a weighted average of the costs of money invested in buildings, land, inventories and net receivables (ie, unpaid bills). The weights come from the data in chart 1.

Getting it

The cost of fixed-interest debt is easy to measure: it is the triple A corporate bond yield. Working out the cost of equity is a little harder. Companies often use the reciprocal of the price-earnings (p/e) ratio as a surrogate. However, equity costs depend on many other factors, the most important being projected dividend growth. They can be high even when p/e ratios are high.

A better estimate of the cost of equity is the rate at which expected future dividends (as perceived by the company's management) must be discounted to arrive at the company's present stockmarket valuation. This way of working out equity costs is analogous to the way the cost or yield of a bond is worked out—namely, the rate at which its coupon stream must be discounted to arrive at the bond's current market value.

Equity costs fall when the market value of a firm's shares rise, because the rate at which the (unchanged) dividend stream has to be discounted falls. Companies often assume that financing investment through retained earnings is cheaper than through rights issues. But both sorts of equity cost the same in America where companies can repurchase their shares at market value.

The cost of equity (so defined) boils down to the sum of today's dividend yield and the projected dividend growth rate. The first is known; the second is the devil to forecast. Dividend growth for companies as a whole will depend on a host of factors: expected inflation; the projected real return on capital; and forecast tax, depreciation and investment allowance schedules.

The overall cost of capital depends on the relative use of debt and equity. Since 1961, the Hatsopoulos study finds that the ratio of debt to total capital rose from about 20% to a peak of 27% in 1972 before falling back to about 22% for the two years 1980-81.

This finding—that balance-sheet gearing is quite modest and is lower today than in 1972—is reassuring. But it contrasts with the diagnosis of other economists and brokers (such as Salomon Brothers) who have gnashed their teeth over a secular decline in equity ratios since the 1950s, and a current debt-equity ratio of almost one. How come?

Some of the difference arises because the Hatsopoulos group looks at companies' net debt (total debt minus liquid assets). The alarmists look at gross debt. The difference is material: in 1981 liquid assets were 20% of total debt. In addition, Mr Hatsopoulos eschews book valuation of debt. He revalues debt by multiplying book values by the ratio of the market value to the book value of bonds quoted on the New York Stock Exchange.

Equity costs are a much more important component of the total cost of money than bond yields. In 1981, the nominal pre-tax cost of equity was well above 30%; triple A bond rates were about 12% (see chart 2).

Since the level of the stockmarket is the key to the cost of equity, it is also a main determinant of the cost of capital. Wall Street's recent boom has done much more to reduce funding costs than the earlier fall in interest rates. The very sharp rise in the cost of money in 1974 was primarily a reflection of the stockmarket's plunge.

Equity is more expensive than debt for two reasons: risk and tax. Investors demand a higher return from equities because bondholders get an earlier crack at the assets of bankrupt companies. The premium on this risk is the gap between bond yields and after-tax equity costs.

Also, under the American (and most other) tax regimes, dividends are paid out of after-tax corporate income while interest is paid out of before-tax income. For equity and debt to command roughly comparable risk-adjusted yields in investors' portfolios, the pre-tax cost of equity has to stand at more than

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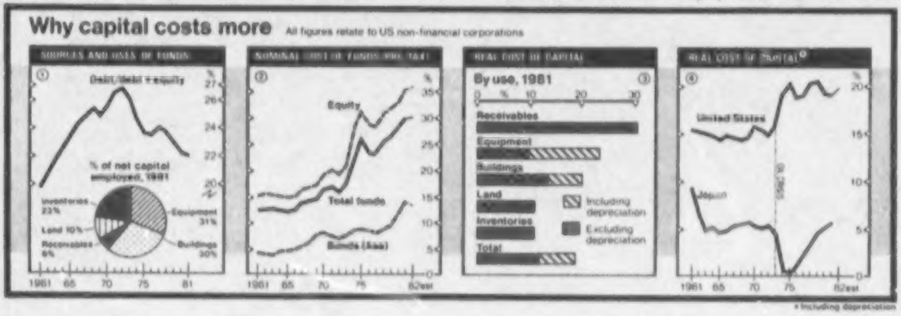
* High cost of capital: Handicap of American industry. By George Hatsopoulos, Thermo Electron Corporation, 101 First Avenue, Waltham, Massachusetts. Figures in our article are drawn from the study, which was sponsored by the American Business Conference.


Why capital costs more All figures relate to US non-financial corporations

* Including depreciation

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twice the pre-tax cost of debt.

Why then do American companies rely so heavily on equity? Mainly, of course, because, come hard times, dividends can be pared and—in extremis—even passed. Bond interest and principal repayments must be met on the nail. But American corporate treasurers also rely on equity out of habit, ignorant of the fact that in 1981, when bond yields hit the roof (namely 14%), equity was even more expensive.

Using it

The cost of raising money is only one element in the overall cost of capital. Each way of using the money incurs a different net cost because of different adjustments for inflation, taxation, depreciation and investment allowances. For example, the cost of fixed assets (equipment and buildings) is the cost of capital plus the cost of depreciation less the benefit from tax credits and investment allowances and less the benefit from inflation.

Depreciation is the dominant factor. In 1981, for example, the real cost of equipment, excluding depreciation, was 9.4%—very close to the real cost of funds of 8.9% (the nominal cost less the expected inflation rate). But, with depreciation included, the real cost of equipment shot up to 23.3% (see chart 3).

Land is straightforward. It does not depreciate—anyway, the taxman does not recognise the possibility. So the real cost of land is the same as the real cost of capital. Effectively, so is the real cost of holding inventories. But the real cost of holding net receivables (unpaid bills) is the full nominal cost of money. Unpaid bills gain nothing from rising prices or tax breaks.

The overall real cost of capital is significantly higher than the real cost of raising money for two main reasons:

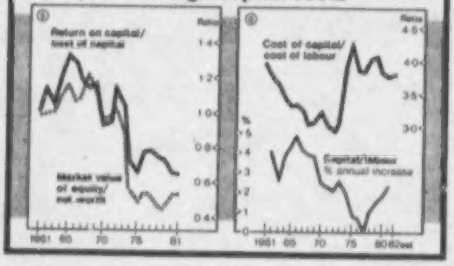
- Depreciation raised the cost of equipment and buildings by about 14 and six percentage points respectively in 1981.
- The cost of receivables is very high (about 30% in 1981) because there is no offset for inflation or tax.

Since 1960, about 60% of all capital raised has been channelled into equipment and buildings, in roughly equal proportions. The fraction spent on land has fallen sharply—from 17% to 10%. The slack has been taken up by inventories (up from 21% to 23%) and net receivables (up from 1% to 5%).

Relative costs have also changed. In 1961, the cost of financing equipment, buildings, land and inventories (net of depreciation) was similar. Since then, tax changes have been biased towards equipment. By 1981, the cost of financing buildings, inventories and receivables had risen by about 40%, 25% and 140%. The cost of buying equipment, by contrast, stayed put. This has favoured basic industries such as steel (which carry large fixed assets) at the expense of high-tech industries (which do not).

In the two decades to 1981, real capital costs rose from 15% to almost 20%. The big jump came in 1974. Of the 3.35 percentage points jump in that year, only 0.35 of a point was due to higher inflation. Three points reflected a steeper real cost of funds—mostly due to the stockmarket's fall pushing up real equity costs.

The price of high capital costs



Over the whole 20-year period, a higher real cost of funds and higher inflation (which pushed up the overall real cost of capital by four points and nearly two points respectively) were mitigated by an increasingly liberal tax regime (which knocked 3.2 points off capital costs).

However, President Reagan's 1981 Economic Recovery Tax Act (which was heralded as a breakthrough) did not help much. A one-point rise in the after-tax cost of capital would be enough to wipe out its effects. Some of the act's benefits will anyway have been eroded by the belt-tightening 1982 Tax Equity and Fiscal Responsibility Act.

Regretting it

There have been at least four important consequences of the high real cost of raising money in America.

- The cost of capital has risen much more sharply than the cost of labour (see chart 6). The result is, although companies are still year-on-year employing more capital for each hour of labour, the capital-to-labour ratio is growing at only 1% a year compared with an average 3.3% a year before 1974.

Mr Hatsopoulos does not accept the argument that the substitution of labour for capital should be encouraged (eg, by abolishing investment incentives). He holds that the route to higher employment is through faster growth, which requires higher capital-labour ratios and which, in turn, waits on a lower real cost of capital.

- Corporate profitability has not increased to compensate for the rising cost of capital. The ratio of the return on capital to its cost has been falling since the mid-1960s (see chart 5). In every single one of the past eight years, the ratio has been less than 80%. Corporate America has not even been covering its costs. At the same time, the ratio of the market value of companies' equity to their net worth has plunged by 50%.

The collapse in equity values during the 1970s has led to the surge of acquisitions and takeovers. When the return on capital is less than its cost, new investment makes little sense. But the same investment, undertaken by snapping up an existing business, can be profitable if assets are acquired at well below replacement cost.

- American companies' high real cost of capital hurts their international competitiveness. Higher productivity in Japan, the Hatsopoulos report suggests, is at least in part due to higher capital investment (twice America's as a percentage of gdp) boosted by extraordinarily low real capital costs.

Until the oil crisis of 1973, the real cost of capital in Japan was about half what it was in America (see chart 4). Since then, the gap has widened. In 1981, the inflation-adjusted cost of capital in Japan was a mere 5½% against 19% in the United States. When depreciation costs are stripped out, the real cost of capital in Japan is consistently negative. This compares with a real rate in the United States of about 13%.

Two reasons for Japan's advantage: (i) Balance-sheet gearing is much higher (on average net debt is probably about 75% of capital employed). But in times of growth, Japanese companies' debt-to-capital ratios can rise well above 75%. Debt of 5-10 times equity is not unusual. (ii) The nominal cost of debt is very low, frequently below expected inflation.

Japan's capital-cost advantage is almost as significant as its better-documented wage-cost advantage. In 1981, says Mr Hatsopoulos, a typical product costing $10,000 to manufacture in America would cost only $4,900 in Japan. The lower marginal cost of capital accounts for 45% of the total cost saving of $5,100.

- American innovation is being squashed by high real capital costs. The economic value of new ideas is very sensitive to the cost of capital. That means that new technologies may be developed profitably in Japan yet remain uneconomic in America. The Hatsopoulos paper calculates that, in order to offset the benefits of lower Japanese capital costs, American venture capital companies need an (unthinkable) subsidy of $6 for every $1 that they raise.

How can America's high cost of capital be reduced? Mr Hatsopoulos is more concerned to identify the problem than solve it. But he does make two suggestions:

(a) Restore the benign macroeconomic conditions of the 1960s—4% inflation, low real interest rates and low equity risk premiums. That would reduce the real cost of capital to about 13½% (a little below the 15% cost of the 1960s owing to more generous capital allowances).

(b) Revamp the tax code. If dividends on cumulative preferred stock had, like interest payments, been tax-deductible the cost of capital to profitable firms would have fallen from 18.8% to 9.8% in 1981. That would have reduced Japan's capital-cost advantage on a product costing $10,000 from $2,300 to just $700.

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Senator GORTON. Thank you both for your interesting and enlightening testimony on this subject.

To follow up on that, I would be happy to have each of you comment on what you consider to be the relative responsibilities of private industry as you represent it, the universities and the Government in asserting leadership in the development of new manufacturing technologies. How do the responsibilities of those three institutions in our society relate to one another?

Mr. O'KEEFE. The Government, universities, and the private sector, you can look at these things, whether it is manufacturing technologies or research and development or what have you, as risk-reward ratios. Generally speaking, industry will work on something like a 5-year planning cycle. In other words, industry can afford to invest when a return of that investment is seeable within something like 5 years.

With respect to new technologies, it is generally the function of the universities to pick up somewhere in the 5- to 15-year range and through a combination of private grants, tuitions, and Government support. Once you get beyond something like 15 years, you are talking about something which neither the private sector nor the university, both of which have to be judged by some specific results, it is beyond their purview, and such items generally fall best into Government policy. And we look at manufacturing just as we would look at research and development.

Mr. ALBERTINE. Mr. Chairman, I would not disagree with any of that. Let me just raise one or two points.

One, I think this is an area where the Government has a very important role as a catalyst to bring our educational institutions together with industry. I am told, for example, that the shadow education system which now exists in industry is about a $60-billion-a-year enterprise on its own I think that the shadow education system may partly be the result of the failure of our universities to seek out the market that exists for their tremendous talent.

I will just give you a concrete example from one of our firms. The firm is Materials Research Corp., which manufactures machinery for the sputtering process. The chairman and founder of that company is Dr. Sheldon Weinig, who is a Ph. D. in metallurgy from Columbia and taught metallurgy at Columbia. He is a person who is very interested in education.

He has a theory that engineers cannot talk and that they ought to learn how to talk, particularly if they are going to sell his products. So he decided several years ago to go to his local university in New York to try to get the university to develop a program to teach his engineers to talk. All of his engineers throughout the company go through a public speaking course. The university said fine, and gave him a catalog and said we have a course which is a semester course that meets Mondays, Wednesdays, and Fridays at 11, and all of your engineers can come to that course. He said, no, no, no, you don't understand. What I want you all to do is come into my plant and run these people through. I want a course which is no longer than 72 hours, because we do not have time to play games. And they, of course, rejected that notion. He went out and on his own hired three public speaking teachers, and they teach a

72-hour course to all his engineers on a rotating basis throughout the year.

That is an example, it seems to me, of a situation where industry and the educational establishment should have gotten together more efficiently.

Senator GORTON. That really anticipates my next question, and that question is: how adverse is the impact of any shortage of intelligently or properly educated scientists and engineers and technicians with respect to these technological problems which we face today, and what ought we to be doing about that?

Mr. O'KEEFE. Well, with respect to the shortage, the shortage is in fact real. The Japanese, of course, are graduating five times as many engineers as we, and the Soviets are graduating five times as many. But the Soviet allocation system is such that only 10 percent of them get engineering jobs, so the Soviets really are not moving forward in that way even though the numbers come out that way.

With respect to solving the problem, I think that our position, my own company's position, is that universities should use their own talents and judgment as to how they proceed. For example, in the Boston area Wang Industries has put something like $15 million into a computer software company. IBM and Digital Equipment have put $40 million into computer operations in universities. Some of that, of course, is self-serving because they want to end up using IBM and Digital equipment.

In my own case, our company, EG&G, has just donated a $5-million computer sciences lab to MIT. By and large we keep these things on a hands-off basis.

Now, for specific operations peculiar to my business, et cetera, we are much more likely to, as others have done, not to dictate the universities as to how they should educate, but to hire individuals who can work 40 hours a week on the specific problem. We maintain that differentiation.

What is the long-term problem? The long-term problem is that we now are stimulated by the usual economic factors and are finding that students do want to go into the sciences and the technologies, and we can get some stimulation—and I used to be chairman of the board of higher education in Massachusetts—and we can move fairly quickly in the higher education areas because the State government is more interested and the industries are. But the real bottleneck is down in the primary and secondary schools where you are dealing with local budgets, towns, and a lethargy of bureaucracy which is much slower to move. And the farther you get down, right down into basic science and mathematics, that is the longer-term problem. I think we will solve the short-term problem.

Senator GORTON. Dr. Albertine, you gave a marvelous insight into the way that the particular industry and the educational establishment did not mesh. How does that relate to Dr. Keyworth's comment on barriers between industry and the basic research establishment? Do we have the same lack of communication there with each of them going its own way? And if so, what do we do about that, and what do we do about the situation you described in connection with your engineers 'speaking problem?

Mr. ALBERTINE. Mr. Chairman, I think the answer is yes. My impression—I am an economist and not a technologist—but my impression from the technologists who run our companies is that when people like Dr. Weinig took a Ph. D. in metallurgy or Dr. Hatsopolous took a Ph. D. in thermodynamics in the early and mid-1950's that the university was the place where the cutting edge research and cutting edge technology existed.

The impression we have now is that it is industry where the cutting edge research and cutting edge technology exists. And I think Mr. O'Keefe's example of donating machinery to MIT is a good one. That is reflected by a lot of our high technology companies. I think this is again an area where Government has a role.

And I would urge this subcommittee, for example, to go up to Massachusetts, maybe to go to Ohio, maybe Ohio State might be an excellent place. I certainly know something about the University of Texas, and I think that would be a wonderful place to go to bring together the educators and the industry people in those areas. I know in Texas, in Austin, Tex., they do not communicate with each other very much, and I think that is a role for Government.

You have a great deal of pulling power with respect to both industry and education, and you have a great capacity for focusing the public's attention on these issues. And I would urge this subcommittee to take it upon yourselves to go around the country and hold confrontation sessions between industry and academia with respect to these issues.

May I comment on one other tangential point on education, because this is something to which we have given a lot of thought?

Dr. Weinig and I were in Japan several weeks ago, and we learned a couple of very interesting pieces of information which I would like to pass on to this subcommittee.

There are, according to Ambassador Mansfield, 12,000 to 15,000 Japanese students studying engineering and chemistry and physics and maybe American studies, maybe advertising or whatever in the United States. Most of those Japanese students are being supported by the Japanese Government and Japanese industry, and, of course, they are learning these subjects in English. There are 500 American students in Japan at the moment, to my knowledge, all of whom are being supported in Japan by their mothers and fathers, and most of them are studying subjects in Japan in English.

There are 1,500 American business people in Japan. A handful of them speak Japanese, and most spend their time at the American Club in Japan.

We believe that if we had 200,000 or 300,000 Americans who really understood the Japanese marketplace and spoke the language, which is certainly relatively relevant to being able to sell in Japan, we could probably manipulate their economy a whole bunch better.

And one of the things we urge this subcommittee to look at is encouraging and supporting American students who are interested in going to Japan, Germany, France, and other parts of the world to learn how to sell in those areas.

Mr. O'Keefe. Could I make two quick comments on that one? I want to put in a couple of caveats.

One is the thing that Keyworth talked about, the difference between the two cultures of the university laboratory and industry and my own comments about the difficulties in managing both things.

Now, I have been both. I have been an entrepreneur who started a company, and I am a reasonably successful man, and we have grown 25, 30 percent a year for the last 30 years. And there is a difference. When you are an entrepreneur—and you will hear this all the time, people complain about it—I do not care whether you are in Bell Labs or in Los Alamos or in my own company—that the research and the entrepreneur, he has to be a little bit unrealistic. He has to strive for some things and see visions that other people do not see.

The function of a manager, however, is to look at a dozen of these entrepreneurs and recognize that they are all going to come out striving for their particular program, and he has to be more pragmatic, more realistic, pick two or three of them, and he is going to have 10 people think he is a clunker.

Now, with respect to the language question, the Japanese do—I had that problem, so I went and learned Japanese, and I speak Japanese enough to get by over there. And the reason they speak English is it is just a lot easier language.

Senator **GORTON**. Mr. O'Keefe, Dr. Albertine, thank you both very much.

The hearing is adjourned.

[Whereupon, at 11:30 a.m., the hearing was adjourned, subject to the call of the Chair.]

ROLE OF TECHNOLOGY IN PROMOTING INDUSTRIAL COMPETITIVENESS

THURSDAY, JUNE 23, 1983

U.S. SENATE,
COMMITTEE ON COMMERCE,
SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, D.C.

The subcommittee met, pursuant to notice, at 9:10 a.m., in room SR-253, Russell Senate Office Building, Hon. Slade Gorton (chairman of the subcommittee) presiding.

OPENING STATEMENT BY SENATOR GORTON

Senator GORTON. Welcome to the second day of hearings on the importance of improving manufacturing in the United States to increase our competitiveness and employment capacity.

Our ability to manufacture a wide range of goods superior to that of our competition has contributed much to our high standard of living and our national security. In 1981, manufacturing provided a quarter of our gross national product, accounting for more than one-fifth of all jobs, and producing $154 billion in goods for export.

However, the number of manufacturing jobs in the United States dropped by 4 our million in the last 4 years, while production of manufactured good fell by 11 percent. A trade deficit of $15 billion for manufactured goods is currently projected for 1983.

In recent years, technological innovations involving computers, automated machines, and exotic sensors have made available enormously improved manufacturing capabilities. At our first day of hearings, however, the President's science advisor, Dr. Keyworth, and the Undersecretary of Commerce for International Trade, Lionel Olmer, pointed out that U.S. industry has been slow in adapting, and no longer leads the world in employing the most modern, productive manufacturing technologies. A National Academy of Engineering panel recently reported the United States is beginning to lose its leadership in manufacturing technologies to Japan and West Germany.

Our universities, traditionally a major source of technological innovation, devote far less attention to manufacturing now than they did perhaps 20 years ago. Dr. Keyworth and other witnesses Tuesday spoke of barriers between industry and university research.

Major technological innovations can lead to manufacturing equipment with greatly expanded capabilities to see, feel, and even learn, relieving humans of dangerous or monotonous tasks in the process. But to bring about such innovations and to regain our technological advantage in manufacturing, additional research appears to be needed in such areas as visual and tactile sensors, machine control strategies and human/machine interfaces, and the sensor information processing. Attention must be paid to the need for training engineers, technicians and managers for manufacturing.

The world may be encountering a revolution in manufacturing as great as that brought about by Henry Ford's adaptation of the assembly line. Those industries and countries able to develop and use these manufacturing methods will have competitive advantages over the rest of the world.

A number of bills related to technological innovation and competitiveness, the focus of these hearings, have been referred to this committee. Among these bills is the Manufacturing Sciences and Technology Research and Development Act (S. 1286), which I recently introduced along with six of my colleagues. The bill's purpose is to help restore American technological leadership in manufacturing through reinvigorating university research with shared participation and funding by industry.

While we heard general comments on this subject on Tuesday, we will get somewhat more specific today and we will start with a group of people from industry who have been extremely helpful to us in the process thus far. We will begin with Mr. Ernest Fenn of the Boeing Commercial Airplane Co.

Mr. Fenn.

STATEMENT OF ERNEST FENN, VICE PRESIDENT, BOEING COMMERCIAL AIRPLANE CO.

Mr. FENN. Mr. Chairman, members of the Senate Subcommittee on Science, Technology, and Space, I am Ernest Fenn, vice president of operations of the Boeing Commercial Airplane Co. We appreciate this opportunity to present our views. In addition to my comments here today, I would like to offer the subcommittee two written submissions from Boeing which focus on the role of the universities in contributing to American productivity improvement.

Mr. Chairman, the bills under consideration today address an important national need where we believe Government action is required, the foreign challenge to U.S. manufacturing productivity and quality. Our domestic automotive and steel industries have suffered major market losses from foreign competition. Our civil aircraft industry is under intense pressure from the European Airbus consortium, and the likely entry of the Japanese by the end of the century.

If the United States is to avoid losing further ground in the arena of international competition, we need to make changes. Draft bills S. 428 and S. 632 are positive steps in assessing our competitive position and providing a mechanism for strategic planning.

Utilization studies are needed to help implementation of viable technologies and identification of retraining requirements. Competitiveness studies will guide us in identifying how we can put the team formed by labor, industry, Government, and universities to work most effectively in meeting the threat.

S. 1286 is of particular importance for improving U.S. advanced manufacturing technologies since S. 1286 makes specific provisions for advancing computer aided design, automated material handling and improved sensing technology.

As an example of this, the manufacture of 757 wings at Boeing has changed dramatically because of these technologies. A design engineer generates a computer representation of a new wing shape. That same computer representation is then used in turn by another designer to specify the location of the fasteners, by the manufacturing engineer to design tools to hold the wing components for joining, and to program an automatic riveting machine to drill and install rivets to assemble the wing.

It was unheard of 20 years ago, but today each wing receives 30,000 holes and rivets without a location error. Even the first 757 wing was made without an error. These wings are being made by the same people, retrained to these new techniques. We estimate that these and related changes have cost Boeing nearly one-half of a billion dollars.

The use of the same information in each task prevents the introduction of errors that used to occur in each distinct task. It ties design and manufacture into a single process and produces a higher quality product through use of several advanced computer and manufacturing process technologies.

Time does not permit me to deal with all of the aspects with involved with improving manufacturing technology, but there is a particular need that deserves your attention.

To meet the competition, industry must build manufacturing systems that can be adapted at any time to take advantage of new materials, new processes, and new product characteristics. At the same time, these systems must be very efficient. To obtain such flexibility and efficiency in the same system requires considerable complexity.

At one time, the university research establishment was the major source of advanced-manufacturing technology. New engineering graduates were well trained in manufacturing technology. This is no longer true. We have allowed the university laboratories and equipment to deteriorate into obsolescence, leading students to believe that manufacturing does not involve sophisticated technology, and turning graduates from manufacturing careers.

Consequently, the capability to perform manufacturing research has declined. Faculty have little incentive to perform such research, and students are not exposed to modern manufacturing equipment.

In meeting the needs posed by foreign competition, the universities face significant obstacles to creating programs. It is extremely costly to equip a university laboratory with state-of-the-art equipment.

Numerically controlled machine tools, computer aided design graphics systems, research data acquisition systems, and even single instruments can cost hundreds of thousands of dollars. Technology is evolving so rapidly that periodic upgrading or changing of equipment is a major expense as well.

The urgent need for improvement of manufacturing technology cannot wait for university budget trends to change. The capability to advance manufacturing technology rests at least in part on the condition of the laboratories and equipment and we cannot expect large improvements in the new graduates until new facilities and additional emphasis on manufacturing are available.

We believe direct grants for university equipment purchases would be an excellent way to obtain near-term and long-term manufacturing technology improvements. Near term because of the almost immediate effects on educational programs; long term because grants would help to reestablish an important manufacturing research capability.

We therefore recommend additional authorizations for university equipment and laboratory grants under section 5 of S. 1286. With or without an equipment grants provision, however, the provisions of S. 1286 are essential to stimulate near-term manufacturing-technology improvements.

Before closing, let me touch on just one more important aspect of S. 1286. This is the provision of section 6 for research on how implementation of advanced manufacturing technologies affects the use of human resources. If foreign competition continues to force new technology introduction, the effects on human resources will become more pronounced.

Industry needs a better understanding of the general consequences of such changes and we need better methods for designing manufacturing systems that take the human resource into account and use it wisely. Managers need a better understanding of the collective consequences of individual actions in manufacturing technology change so that appropriate policies, training programs and production systems can be developed. Increased attention to this kind of research will be very important to future industrial policy.

In summary, it will be necessary to provide for effective and continuing research and development, for human resource development and training, and for timely capital investment to recapture a leadership position for American manufacturing.

Thank you.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR GORTON AND THE ANSWERS THERETO

Question. Other witnesses have identified barriers or, in some cases, simply a lack of close ties between industries and the university research community. These barriers, or lack of ties, appear to restrict the flow of manufacturing innovation.

Would S. 1286 help to overcome these barriers?

Answer. A number of provisions in S. 1286 do address certain of the recognized barriers in the following ways:

Grants for manufacturing research and for Cooperative Research programs are directed at key technologies expected to yield considerable productivity gains.

The emphasis on Cooperative Research centers will provide considerable industrial advice on the practical needs of industry and the reporting and schedule requirements necessary to technology transfer and use. The interaction will also provide industry with a better perception of the long-term basic research of the universities.

S. 1286 also provides for research on the utilization of manufacturing technology knowledge. We believe continued research in this area is appropriate when it is recognized that a major part of American productivity problems result from a failure to use existing knowledge and techniques to improve production. Research is needed to understand how and why managers found this acceptable.

S. 1286 realistically addresses the fact foreign technology initiatives must be taken into account in any national industrial policy. Both governments and firms need to recognize these activities in their plans. Provision for studies of these issues will assist in formulation of realistic public and private sector research priorities.

Perhaps the most important provision of S. 1286 is to create an advisory board for these programs. identification of truly important research priorities will be difficult, but would be rewarded with improved industrial and university research vitality.

Question. What other legislative changes would you suggest to address these barriers or to create closer cooperation?

Answer. One major point made in our testimony was that many universities having excellent educational programs, lack manufacturing technology laboratory equipment. It is a severe deficiency in that it inhibits the educational programs, and prevents meaningful research because of incapability. Legislation providing direct equipment and faculty development grants for manufacturing education and research would be very appropriate.

Industry donation of new or surplus modern manufacturing equipment and instruments can enhance university-industry interaction by increasing the research capability of the university as well. Legislation providing improved tax incentives for such donations may also be appropriate.

Industrial concern over the effectiveness of focussed university manufacturing research could be reduced by research grants which reward programs showing schedule responsiveness and concern for technology transfer. Legislation providing for such incentives or rewards would be desirable.

Last, legislation to encourage university continuing education in manufacturing technology is desperately needed. Current faculty and laboratory facilities are not adequate nor sophisticated enough to provide a continuing education in manufacturing technology. We consider this a serious problem because the earliest and greatest productivity gains will be obtained through the existing stock of manufacturing engineers.

Senator GORTON. Thank you very much, Mr. Fenn. We will proceed through the rest of the panel before we have questions for any of you. We do have a fourth member of this panel. If Mr. Arnold Cantor of the AFL-CIO is here, we would appreciate his coming up and joining the panel.

Our next witness is Mr. Donald Domnick of the Caterpillar Tractor Co. He may proceed.

STATEMENT OF DONALD DOMNICK, VICE PRESIDENT FOR MANUFACTURING, CATERPILLAR TRACTOR CO.

Mr. DOMNICK. Thank you, Mr. Chairman.

My responsibilities as vice president of manufacturing and facilities planning include seeking out and/or developing on our own and then implementing the most cost-effective manufacturing technology we can come up with. Our company has been known as a manufacturer of quality products for over 50 years. The support and extension of this reputation has required a concentration of effort in developing and implementing manufacturing technology over that entire period.

Senators, I wanted to cover three separate points with you this morning and do it rather briefly. I would like to tell you what we are doing at Caterpillar in manufacturing technology. I would like to explain what our non-U.S. competition and their governments are doing, and third, I would like to describe how a program such as the one proposed in this particular bill can succeed.

I would like to point out we are in full support of S. 1286. Historically, we have been engaged in the manufacturing, fabrication and assembly of product. We have strived to apply technology in the manufacturing areas to insure the highest quality products in our market as well as initiate new concepts and new approaches that can be used throughout our manufacturing facility.

As an example, Caterpillar recently developed a totally new concept in crawler tractors. I have a model in front of me. These machines are characterized by the triangular shape of the tracks, in contrast to the normal oval shape of tracks, with the drive mechanism up at the top, getting it out of the dirt, the mud, and all of the abrasiveness that you find down in the ground-engaging area.

We also have developed bogie systems that flex with the ground conditions to get more track on the ground and, therefore, more power utilized out of the engine. To do this, obviously, takes a lot of development in manufacturing technology. This is design technology, but to accomplish the things our engineers put on paper required a considerable amount of development in technology.

One of the things in manufacturing was our ability to seal and lubricate the tracks so that we have a lifetime sealing and do not have to go around daily to grease all of the fittings underneath there. This was quite an undertaking and we came up with several approaches.

The first was very successful, but we made improvements on it with a new seal that now gives us what we call SALT. I know that is a little different meaning than you have here on the Hill, but it means sealed and lubricated track at Caterpillar.

To develop the mechanisms to produce these things in the quanitities we are talking about, we first had a two-piece seal. Now we have a three-piece seal, and this has taken a lot of development in technology. I wanted to give that as an example of some of the things we have to contend with in developing technology.

Last year, Caterpillar invested $376 million in its research and engineering effort. An important part of this was our manufacturing research and manufacturing-engineering portion of that.

Operating from different departments within our company, there are many hundreds of engineers and technicians who work on inventions, techniques, and systems to improve our manufacturing capability. We have some 120 engineers working full time on strictly manufacturing research and development.

We are also heavily engaged in the use of electronics in manufacture. Computer-aided design and computer-aided manufacturing approaches that Mr. Fenn talked about are the coming thing and all of us need to continue development in this area.

This serves to integrate product design with product manufacture. That is the key to being cost effective, to be able to use the electronic media to convey design concepts into commands that are delivered right out to the machine-shop floor and put through the computer so that we can operate machine tools without a lot of extra hours in office time.

An important manufacturing application of computers is in the area of welding, also. Caterpillar has, for a number of years now, used more welding consumables than any other company in the United States. Because of that, we have devoted a lot of our technology development time to control cost on processes and mechanized systems to fabricate portions of our product under control conditions with a minimum amount of labor.

For welding and other applications, Caterpillar now has 80 robots and we expect to have 700 operating by 1992. To do so will require a heavy commitment to the development of new technology. You do not just take a robot and put it in. You have to develop a technology on how to use it.

Application today in robots for welding is largely contained in spot welding, as in the automotive industry. But, because of the massiveness of our material and the heavy welding, we have to do more in the way of developing robots for that heavy weld. We now have 14 robots that do all of the welding on these bogies I talked about under here. All of the welding on those particular parts on all of our tractors are now made by robots.

As far as the welding is concerned, we have not perfected the complete automation of the machining of those robots. In a similar way, we are using robots in material handling, machine loading, painting, assembly, and foundry applications.

We plan to continue to emphasize the development of manufacturing technology and we will devote increased efforts over the next few years because it is such an important part of cost control. Assistance is welcomed from the Federal Government to augment our internal efforts. The force of worldwide competition makes it essential that we continue to lead the world in innovative concepts and manufacturing methods.

You are probably aware that Caterpillar has consistently been a strong exporter since World War II. Our exports have increased over this period with an increasing percentage of our domestically produced product being shipped overseas. This has resulted in Caterpillar's being a leading contributor to the favorable balance of payments.

For the 5-year period 1978 through 1982, Caterpillar's net contribution to the U.S. balance of payments totaled $12.6 billion. In past years, our competition has been largely domestic in nature and, although we still have important U.S. competitors, we feel the greatest pressure from internatonal comptetitors, particularly from Japan and Italy.

Mr. Chairman, we cannot be precisely accurate or sure of the role that foreign governments play in supporting their industries in such matters as manufacturing development. It is common knowledge, however, that the Japanese attribute a large measure of their success to their ability to direct government, education, and industrial resources toward a common goal that is best for Japan.

The Japanese Ministry of International Trade and Industry provides a common umbrella under which intellectual and physical resources can be focused to the job at hand. The results, as you know, have been phenomenal.

The Japanese have been successful in conquering markets in many industrial sectors throughout the world. In our industry, Caterpillar is no exception. Our major rival has its home base in Japan.

Similarly, the Italian Government makes resources available and provides financial incentives to broaden the technical base of their industries. The result is continuous innovation, improved products, increased exports, and the resultant continued and expanded employment.

Competitors in the earthmoving industry, such as Komatsu, Fiat, and IBH, do not reveal information concerning the government assistance they receive in the development of manufacturing technology, but our sources and other close associations make it seem quite likely that it is extensive.

The United States, in contrast, has not developed a cohesive effort to insure the advancement of manufacturing technology. As a result, within an industry, the lack of close ties to education and the concern over possible legal consequences resulting from the cooperation of individual companies, American industry has tended to be isolated, company by company. And the present recession, with its associated cost pressures, has caused many companies to reduce their work force and often hampered their capacity to further develop technology in manufacturing.

American industry does not expect the U.S. Government to develop our technology. The Government can, however, serve a useful role as a catalyst for expansion and broadening of the scope of manufacturing technology.

S. 1286 will foster such expansion. It provides the funding as seed money for improving manufacturing technology capable of serving many American industries.

Thus, Caterpillar supports S. 1286 and urges this committee to report it favorably. In supporting the bill, we urge the program be structured in a matter that will not only be conducive to close relationship between industry and education but will, in fact, encourage such close cooperation.

In many cases, industry has machinery, equipment, and machine tools that have some degree of availability for use in technology development. At the same time, universities find themselves with expertise, educational qualification, and technical breadth not common to industry, but they lack the physical resources. Certainly, where these conditions exist, there is an opportunity for a relationship of cooperation that would benefit all.

To be successful, such a program must be carefully organized. Not every company has the desire or capability to be a partner in such an undertaking. Nor are all universities equal in terms of their emphasis on manufacturing and manufacturing-oriented technology.

On the other hand, nearly 30 schools offering or seeking accreditation in manufacturing engineering or manufacturing-engineering technology have the faculty and commitment to technologies utilized in manufacturing. The success of programs developed under S. 1286 will depend on how well the strengths of the universities and businesses involved are matched together.

Other sources promising capability in this regard include industrial associations, research establishments, and technical societies. Research institutions, such as Battelle Memorial Institute, have demonstrated capability to work closely with industry in the past and to bring resources to bear not common to most industrial employers.

The Society of Manufacturing Engineers has, within its membership of 70,000, a technical activities counsel made up of volunteers that represent a cross section of the American-manufacturing industry. Such talent already assembled could be tapped to assist in the direction of programs such as are contemplated by this bill.

Funding, in our view, must be specific. Joint efforts between a specific company and a school, applied for a clearly identified purpose, merits top consideration. Projects such as developing vision and tactile sensing for industrial robots, CAD/CAM developments, and small-lot flexible-manufacturing cells are examples where emphasis is needed.

We, in the Caterpillar manufacturing organization, endorse the intent embodied in the bill and we urge this be brought to fruition as an example of the very kind of cooperation this bill is designed to encourage.

Senator GORTON. Thank you. Mr. James Dykes of General Electric will testify next. Before he begins we understand Mr. Cantor will not be here, but the AFL-CIO will be represented by William Cunningham. If he is here and will come up to the front table, he will speak after Mr. Dykes. Mr. Dykes.

STATEMENT OF JAMES DYKES, VICE PRESIDENT AND GENERAL MANAGER, SEMICONDUCTORS DIVISION, GENERAL ELECTRIC CO.

Mr. DYKES. Good morning, Mr. Chairman and members of the subcommittee. I am James E. Dykes, vice president of the General Electric Co. and general manager of our semiconductor business division headquartered in Research Triangle Park, North Carolina.

I am pleased to have the opportunity to testify regarding the Manufacturing Sciences and Technology Research and Development Act of 1983. Before I get to the bill itself, however, I think it would be useful to briefly describe the scope of the General Electric Co. This will give you a better understanding of the business environment I represent and, thus, should provide a clearer context for my comments on the bill.

General Electric is the world's largest diversified company. We provide more than 2,000 different products and services to customers throughout the world. These include consumer electronics, engineered materials, electrical generation, and distribution and transmission equipment, factory automation systems, robotics, locomotivies, aircraft engines, microelectronics, consumer and business credit services, diagnostic medical equipment, motors and military defense systems.

In 1982 our 367,000 employees generated more than $26 billion in sales. Last year, GE exports contributed $4 billion to the positive side of our balance-of-trade account.

A goal of General Electric is to become the world's most competitive enterprise, the lowest cost producer of the highest quality goods and services. To help reach that goal, we have invested very substantially in research and development, in productivity improvements, and in upgrading our employees' skills. These investments, I might add, were increased, not decreased, during the recent recession.

We recognize that our own efforts to make GE competitive are inextricably tied to the overall competitiveness of the American industry, and we welcome the attention you and other Government leaders are giving to this issue. Senate bill 1286 is an indication that America's competitiveness transcends party lines and has become a truly national concern.

The stated purpose of this act is twofold. One, to establish a program for research leading to more efficient manufacturing technologies. Two, to encourage greater utilization of those technologies.

It is the second purpose, the utilization of technology which I believe is most important. While not denying the need to develop new technologies, I suggest it is the failure to utilize existing technology that is often responsible for much of manufacturing's productivity problems.

I see many examples of this. Not long ago, one of our own engineers was visiting several Japanese companies to study their manufacturing process. He noticed that the Japanese seemed a bit amused by his curiosity. Finally, one of them said to him, "Where do you think all of this came from, anyway?"

From America, of course. In fact, the most prestigious award for productivity improvement in Japan is named in honor of Edward Demming, an American.

Today we already have the technology to make American manufacturing more competitive. But we are not using it, while our international competitors are.

One example is numerical controls, relatively simple computerized devices for running machine tools. They have been available for years, yet only about 5 percent of American industry is using them today. I could give you a more graphic example from a couple of exhibits I have brought, should you want to review it during the question and answer period.

Another example is automation. Many of our foreign manufacturing competitors are introducing it at a much faster rate than we are. Sometimes managers shun current technology because they are waiting for the newest state-of-the-art when it becomes available. But that may not be what they really need, as we discovered when a group of GE managers was asked to study their businesses and report back on opportunities to use robots.

One hundred and seventy applications were discovered. What is significant is most were not for highly sophisticated robots in the $50,000 to $250,000 class. The majority were for simple pick-and-place robots, costing between $10,000 and $50,000. So the newest technology is not necessarily the best remedy for every problem.

We hear a lot today about the future golden age when newly invented technology will make our current production problems obsolete. The truth is for American industry manufacturing, the future is now.

Certainly newer, better technology is being developed, but it will probably take years to become commercially available. Unless American industries make wise investments in today's technology, they will not be around later to take advantage of whatever is available then.

General Electric has made a major commitment to revitalizing our Nation's manufacturing industry. We have invested more than one-half billion dollars in the last 2 years in new products, acquisitions, and technology which can make them more productive.

The medicine for curing manufacturing productivity problems is available today. But the individual decision whether to take it can only be made by the patients, the managers of those ailing industries. Government cannot make it for them.

Yet, wise Government policies can certainly help make those decisions easier. One such policy would be the periodic reexamination of Federal laws and regulations to insure they are not unnecessarily inhibiting industrial productivity. I am glad to see that section 7 of your bill provides for such a study.

A second requirement for technology utilization is an adequate supply of trained workers. Many of these can be men and women from declining industries who have been retrained. Not only does retraining make sense from a humanitarian perspective, it is also vital to America's productivity.

A properly retrained worker often brings experience and dedication to a job unmatched by a beginner. Right now industries are developing many different retraining plans.

The utilization program specified in section 6 could be useful by evaluating existing plants as well as experimenting with new ones. The required U.N. report could become the major source of information in industrial retraining programs.

Since it is the application of technology rather than its development which I see is the problem, I believe the cooperative agreements created in section 5(c) would be beneficial. General Electric has participated in several State-funded consortia and found them valuable.

My own division, the semiconductor business, chose the Research Triangle Park for its location because it was the home of the microelectronics center of North Carolina. Created by a $24 million State grant, the center supports microelectronics technology development and training at five universities. GE is a major contributor.

We have also contributed $500,000 to date toward the construction of the Center for Industrial Rennovation at Rensselaer Polytechnic Institute. Started with a $25-million appropriation from New York State, the center will among other services accept contract work to find solutions to long-term manufacturing problems.

There are two parts of the bill which I think need greater clarification in order to be effective. First in section 5(b) the selection criteria for recipients of grant should be more explicit.

The current language simply states "grants shall be made on a competitive basis" without specifying the criteria on which such competition will be judged. I would suggest applicants be required to demonstrate a clear need for such research as well as a commitment to use the research results to enhance manufacturing productivity.

Private firms in particular should be required to back up their expression of need with investments of their own funds perhaps on a matching basis. The point is that rigorous selection criteria are needed to guarantee as much as possible that the money is actually spent for the purpose of improving our manufacturing capability.

The other part of the bill which I think needs further clarification is section 7 which directs the Secretary of Commerce to conduct competitiveness studies on specific domestic technology sensitive industrial sectors to determine their "long-term capability for remaining competitive especially with industries in foreign countries." The danger I see here is that a noncompetitive assessment by the Secretary not only might harm an industry's ability to attract capital but is also likely to increase pressures for protectionist measures.

Therefore, I suggest the scope of the competitiveness studies be narrowed to apply more specifically to the bill's overall objective, that is, the production and adoption of more efficient manufacturing technologies. The studies' mandate currently described in section 7(a) is too broad and runs the risk of being used to pick winner and loser industrial sectors. Such a second guessing of the marketplace I think would be unwise.

Thank you very much.

[The following information was subsequently received for the record:]

QUESTION OF SENATOR GORTON AND THE ANSWER THERETO

Question. Other witnesses have identified barriers or, in some cases, simply a lack of close ties between industries and the university research community. These barriers, or lack of ties, appear to restrict the flow of manufacturing innovation. Would S. 1286 help overcome these barriers? What other legislative changes would you suggest to address these barriers or to create closer cooperation?

Answer. The U.S. has a long history of strong university-industry relations and today, those relations seem stronger than ever. Virtually every major university in the country has entered into an industry-university research arrangement of one sort or another, whether it be a university affiliates program, a research institute supported at least in part by individual firms or a consortium of firms, or simply contracts and consulting arrangements with individual faculty members. NSF reports that industry now funds about 6-7 percent of university R&D, and that support in constant dollars has doubled since 1965. As I indicated in my testimony, GE strongly supports such arrangements. To cite just one example, our Corporate R&D lab alone maintains membership in industrial affiliates programs at 7 universities, has research agreements totaling over $600,000 with 15 universities, retains 40 consultants affiliated with 24 universities, and 40 of its staff hold adjunct appointments at 11 different universities and colleges.

Recently, there have been minor difficulties arising out of some universities requiring title or other ownership rights in industry-funded research. This tends to impede rather than help the commercialization of research accomplished in the university. However, this is a matter to be worked out between the university and the industry sponsors and does not appear to be an area requiring legislative action.

QUESTION OF SENATOR RIEGLE AND THE ANSWER THERETO

Question. Please summarize the jeopardy to the U.S. that each of you sees should we fail—over the next 5, 10 or 15 years—to move forward significantly in improving productivity and technology.

Answer. There is no way we can remain competitive in worldwide markets unless we move forward significantly to improve productivity and technology. The reason is that we face ferocious multinational competition both from industrialized country firms like the Germans, Dutch and Japanese who are strategically focused on productivity improvement, and from developing countries like Mexico, Singapore and Malaysia with comparatively low labor rates. Our Sector Executive James A. Baker has been going around the country telling people that American industry faces three choices in the eighties: automate, emigrate or evaporate. Obviously as U.S. manufacturers we prefer to stay here, and we believe that, overall, the productivity advances we achieve through automation will grow many of our young businesses and revitalize some of the old ones.

The present American productivity problem—which is very real—is at least in part the result of management failure to employ technology that has been available for quite some time. Unless we get moving on this problem, we're going to see more loss of domestic and world market share and even business failures in the private sector, and increased pressure for protectionism in the public sector. That must not happen.

QUESTIONS OF SENATOR LAUTENBERG AND THE ANSWERS THERETO

Question. Mr. Dykes, in your testimony, you state that General Electric has invested more than a half-billion dollars in the last two years in new products, acquisitions and technology which can make them more productive. Could you please provide a breakdown of those investments by the three categories? For example, it would not be very impressive to find that of the $500 million, $490 million has been invested in acquisition.

Answer. The breakdown of the $500 million that GE's Technical Systems Sector alone has spent over the last two years to improve the productivity of our nation's manufacturing industries is as follows: 6 percent went for new products, 21 percent for technology and 73 percent for acquisitions, primarily of Intersil, a pioneer in integrated circuit design, processes and manufacturing, and CALMA, a technology leader in interactive graphics systems. These acquisitions are not portfolio investments. They were made because they fit the overall corporate strategy of moving fast into a program to design, build, operate and sell the advanced products, systems and services that will be needed in the automated "factory with a future." What we have done is taken the vast resources of the General Electric Company—financial, technical and marketing—combined them with the talents of two fine companies, and focused them all on the job of revitalizing the factories of the U.S.

In addition, the Company has invested more than $800 million in new equipment in the last two years to update our own factories and offices for greater productivity and efficiency. GE right now, for example, is in the process of making the largest single factory automation investment in its history. It isn't occurring in any of our "high tech" businesses, but rather in a 70-year-old factory in Erie, Pennsylvania, headquarters of a business started by Thomas Edison—locomotives.

It is this kind of productivity-improving investment we envision occurring in America's old as well as new factories and we're gearing up to meet that challenge.

Question. Mr. Dykes, what percentage of General Electric's overall business is in the manufacturing area, as opposed to the service area?

Answer. Approximately 80 percent of GE's 1982 earnings came from manufacturing and materials, including natural resources, and 20 percent from services.

Senator GORTON. Thank you, Mr. Dykes. We have a statement from Senator Bentsen on this subject which will be inserted in the proper place in the record, and I believe this is Mr. Cunningham for the AFL-CIO.

Mr. CUNNINGHAM. Yes.

Senator GORTON. Because of schedule problems with our robot, we must complete this panel within 15 minutes. Your testimony will be included in the record in full. We would appreciate it if you could summarize its most salient points orally.

STATEMENT OF WILLIAM CUNNINGHAM, AFL-CIO

Mr. CUNNINGHAM. Arnold Cantor regrets he couldn't be here today and asked me to come in his place. We are pleased to have this opportunity to testify on means to improve the ability of U.S. manufacturing industries to compete and generate employment opportunities.

S. 1286 would provide funds for the development of new production technologies, studies of competitive problems and experimental job training programs.

We believe it would be more appropriate to place the job training program in the Labor Department rather than the Commerce Department as called for by the bill. That would serve for the need of coordination for job training programs.

I believe the approach in S. 1286 represents an important contribution to the nation's research and development effort and the research needs of policy makers.

These programs would in our view represent a beginning effort and commitment toward the restoration of U.S. industrial health. We do, of course, feel the Congress should go much further and address other aspects of the decline in U.S. manufacturing industries.

Major problems of U.S. manufacturing that need to be addressed in addition to the development of new technology include the rapid diffusion of U.S. technology to foreign firms, the effects of an overvalued dollar and other trade problems, and high interest rates that raise the cost of new investment. The AFL-CIO believes that a comprehensive reindustrialization policy is needed to cope with these problems.

The rapid diffusion of technology means that new technology does not by itself assure an advantage that will protect the Nation's manufacturing base. A number of mechanisms exist that enable new technology developed in the United States to be quickly incorporated into foreign plants competing with the United States.

One factor is the multinational structure of U.S. corporations. Often the foreign competitor is an American firm producing abroad. As new factories are built by U.S. firms in other countries the latest technology is used taking away any advantage U.S. plants have from U.S. developed technology.

Several factors give Japanese and other foreign firms easy access to U.S. technology. Advanced production equipment is often produced and sold by firms who did not produce the final products. These firms are willing and anxious to sell advanced production equipment to foreign firms in direct competition with the United States.

The foreign companies gain access to new technology from U.S. patent sharing agreements with U.S. firms or purchasing the rights to use U.S. technology. Foreign firms may also buy American companies or set up subsidiaries in the United States which hire Americans who have experience with other high tech firms.

The new microcomputers from Japan are an example of the rapid transfer of U.S. technology. Mitsubishi electronics recently announced a new microcomputer that uses U.S. technology and will compete in the already overcrowded microcomputer market. A Mitsubishi spokesman said the new Japanese computer was designed by American engineers at the company's facilities in California but will be manufactured in Japan.

The Japanese and other competitors do not necessarily need a technological lead to disrupt American industry and create job losses in high tech and other industries. Even if they lag in getting products to market or utilizing the latest production technology, they can still wipe out production capability in the United States. Eventually, of course, American industry weakened by the loss of production capability may lose its technological capability as well.

The arrangements which American firms enter into that result in the transfer of technology including technology licensing, joint ventures, and patent sharing are often the result of frustration from the U.S. firms' attempt to export to other nations with strict import controls. Seeing no opportunity to export, they enter into arrangements that deprive the U.S. economy of the benefits of domestically generated technologies.

American competitiveness has been seriously damaged by the overvalued dollar and the debt problems of other countries. Since the first quarter of 1980 the trade weighted value of the dollar has increased by more than 35 percent against major industrial countries.

In addition to making imports cheaper and increasing the price of U.S. exports the high value of the dollar encourages U.S. firms to produce abroad rather than export from the United States. The debt crisis in developing countries has greatly reduced U.S. exports to these countries.

Mexico, for example, has reduced imports of U.S. goods by 60 percent and Argentina by 40 percent. The trade and investment policies and the unrealistic exchange rate will continue to impede the export of U.S. goods and increase imports.

The future of the U.S. economy depends upon a sensible approach to imports linked with revitalization policies for U.S. industries. Interest rates are a major problem hampering recovery, raising the cost of doing business, and impeding industries' competitive ability. The AFL-CIO believes the government must use its authority to allocate credit to ensure credit resources are available to productive investments at reasonable interest rates.

To do so in our view will require the willingness to use credit allocation authority to prevent speculative demand for credit from growing to the extent that it raises interest rates to unreasonably high levels. A common feature of countries which have grown faster than the United States is a use of a coordinated industrial policy.

Many of these countries establish industrial policy through a mechanism including the views of labor, industry and the public. The United States on the other hand has too long been at the mercy of a series of economic schools each claiming to represent the virtues of the unseen hand. The United States must begin to take an active and positive approach toward dealing with the problems facing American industry and to return its vitality and growth.

The United States must maintain its technological leadership, and the AFL-CIO supports legislation like S. 1286 that would contribute to technology development. For the reasons discussed in this testimony, the development of high technology is no longer by itself the issuance of a viable manufacturing base. The problems contributing to the decline of American industry should be approached in a comprehensive manner in the context of a reindustrialization policy so the United States can realize the full benefits of its technological capability.

Thank you.

[The statement follows:]

STATEMENT OF ARNOLD CANTOR, ASSISTANT DIRECTOR, THE ECONOMIC RESEARCH DEPARTMENT, AFL-CIO

We are pleased to have this opportunity to testify on means to improve the ability of U.S. manufacturing industries to compete and generate employment opportunities. S. 1286, the "Manufacturing Sciences and Technology Research and Development Act," would provide funds for the development of new production technologies, studies of competitive problems and experimental job training programs.

This bill would empower the Commerce Department to make grants and cooperative agreements with nonprofit research institutions, universities, private industry and industry groups to do research to develop more efficient manufacturing processes utilizing the latest technology. The commerce Department could also establish centers for manufacturing research and technology utilization to do applied research on manufacturing methods.

The bill would provide funds for competitiveness studies to consider the adequacy of technology currently used in the U.S. to produce goods, the technologies used by foreign competitors requirements for scientific and technical personnel, and the legal environment.

Experimental job retraining programs for workers displaced from declining industries would be provided for by S. 1286 to identify the best means of training workers to work with advanced manufacturing equipment. We believe it would be more appropriate to place the job training programs in the Labor Department along with other existing training and retraining programs rather than in the Commerce Department as is called for in the Bill. Placement in the Labor Department would serve the need for coordination of job training programs.

We believe the approach in S. 1286 represents an important contribution to the nation's research and development effort and the information needs of policymakers. These programs would, in our view, represent a beginning effort and commitment toward the restoration of U.S. industrial health. We do, of course, feel the Congress must go much further and address other aspects of the decline in U.S. manufacturing industries.

Major problems of U.S manufacturing that need to be addressed, in addition to the development of new technology, include the rapid diffusion of U.S. technology to foreign firms, the effects of an overvalued dollar and other trade problems, and high interest rates that raise the cost of new investment. The AFL-CIO believes that a comprehensive reindustrialization policy is needed to cope with these problems.

The rapid diffusion of technology means that the development of new technology does not by itself assure an advantage that will protect the nation's manufacturing base. A number of mechanisms exist that enable new technology developed in the U.S. to be quickly incorporated into foreign plants competing with the U.S.

One factor is the multinational structure of American corporations. Often the foreign competitor is an American firm producing aborad. As new factories are built by U.S. firms in other countries, the latest technology is used taking away any advantage that U.S. plants have from U.S. developed technology.

Several factors give Japanese and other foreign firms easy access to American technology. Advanced production equipment is often produced and sold by firms that do not produce the final products. These firms are willing and anxious to sell advanced production equipment to foreign firms that are in direct competition with American firms.

Foreign companies gain access to new technology from the U.S. by patent-sharing agreements with U.S. firms or purchasing the rights to use U.S. technology. Foreign firms also buy American companies or set up subsidiaries in the U.S. which hire Americans that have experience with other high tech firms.

The new Japanese microcomputers are an example of the rapid transfer of U.S. technology. Mitsubishi electronics recently announced a new microcomputer that uses U.S. technology and will compete in an already crowded microcomputer market. A Mitsubishi spokesman said that the new Japanese computer was designed by American engineers at the company's facilities in California, but will be manufactured in Kamakura, Japan.

Korea has place a top priority on development of a high tech industry. A major Korean electronic company has facilities in the U.S. which it uses to transfer technology from the U.S. to Korea, and another Korean electronics company plans to open a U.S. based technology-transfer office in California according to news reports.

The Chairman of the Computer Science Department at the California Institute of Technology has described the way that the technology for optical fibers was transferred to Japan. A Japanese post-doctoral student, participating in a one-year program, worked with a Cal Tech professor who pioneered in the development of integrated optics and semiconductor lasers. The student returned to Japan with the knowledge and now Japan is the leader in that technological area.

The Japanese and other competitors do not necessarily need a technological lead to disrupt American industry and create job losses in high tech and other industries. Even if they lag in getting products to market or utilizing the latest production technology, they can still wipe out production capability in the U.S. Eventually, American industry weakened by the loss of production capability may lose its technological capability as well.

The arrangements which American firms enter into that result in the transfer of technology to foreign firms, including technology licensing, joint ventures, tightly controlled local investment, and content arrangements, are often the result of frustration in the U.S. firms attempt to export to other nations which have very strict import controls. Seeing no opportunity to export, they enter into arrangements which effectively deprive the U.S. economy of the benefits of domestically generated technologies.

American competitiveness has been severely damaged by the overvalued dollar and the debt problems of less developed countries. Since the first quarter of 1980, the trade-weighted value of the dollar has increased by more than 35 percent against major industrial countries. In addition to making imports cheaper and increasing the price of U.S. exports, the high value of the dollar encourages U.S. firms to produce abroad rather than export from the U.S.

The Administration has steadfastly refused to take specific action to relieve the exchange rate problem. Ironically, they claim that the budget deficit is the culprit which keeps interest rates high. The huge budget deficits are a factor, but they result from the Administration's ill-conceived tax breaks to business and the wealthy, the long and deep recession, and big increases in defense expenditures without matching increases in revenues. Upheaval in the financial markets has clearly contributed to keeping interest rates high as the competition for deposits has grown uncontrollably.

The debt crisis in developing countries has greatly reduced U.S. exports to these countries. Exports to these countries were the greatest single source of export growth in the 1970s. This growth was fueled by the enormous amount of international borrowing, which has effectively come to a halt as countries such as Mexico and Brazil struggle to roll over mountains of short-term debt. The rescheduling agreements, following conditions set down by the International Monetary Fund, force the borrowing countries to sharply curtail their imorts of U.S. goods. Mexico, for example, has reduced imports of U.S. goods by 60 percent and Argentina by 40 percent.

The trade and investment policies and the unrealistic exchange rate will continue to impede the export of U.S. goods and increase imports. Calls for foreign countries to tear down their barriers to trade as a solution to problems of U.S. manufacturing are unrealistic and inadequate. The future of the U.S. economy depends upon a sensible approach to imports linked with revitalization policies for U.S. industries.

U.S. trade law should be strenghtened to require the International Trade Commission to evaluate more accurately and quickly the impact of imports upon an industry and its workers and to fashion a specific remedy to alleviate the adverse effects of such imports. A determination by the International Trade Commission that a remedy is needed for trade injury should not be overturned by the President except with the explicit agreement of Congress. Although earlier relief from trade injury is a concept embodied in U.S. trade law for 20 years, it has been a hollow promise.

Measures such as the Fair Practices in Automotive Products Act and the Fair Market Share for Apparel Imports Resolution are needed to address the problems of specific industries.

In the late 1970s, the complaint of a capital shortage was often heard as interest rates climbed to record levels. At the same time, borrowing for speculative purposes was soaring, putting upward pressure on interest rates and competing with borrowing for productive purposes. Foreign lending, although it did not receive much attention at the time, was growing rapidly leading to the present overextension of U.S. banks to foreign borrowers and also competing with investors seeking funds for productive investments in the U.S.

Interest rates are a major problem hampering recovery, raising the cost of doing business and impeding industries' competitive ability. The AFL-CIO believes that the government must use its authority to allocate credit to ensure that credit resources are available to productive investment at reasonable interest rates. To do so, in our view, will require the willingness to use credit allocation authority to prevent speculative demand for credit from growing to the extent that it raises interest rates to unreasonably high levels.

The problems of U.S. manufacturing industries can be solved by policies that expand noninflationary production and employment with fairness and equity.

A common feature of countries that have grown faster than the U.S. is their use of a coordinated industrial policy. Many of these countries establish industrial policy through a mechanism that includes the views of labor, industry and the public. The U.S., on the other hand, has too long been at the mercy of a series of economic schools each claiming to represent the virtues of the unseen hand. The U.S. must begin to take an active and positive approach toward dealing with the problems facing American industry and to return its vitality and growth.

The AFL-CIO has endorsed the creation of a tripartite National Reindustrialization Board, which would include representatives of labor, business, and the government, to jointly identify and target industrial sectors and regions where increased investment levels are needed.

To provide financing of activities guided by the National Reindustrialization Board, the AFL-CIO supports creation of a financing agency, patterned after the Reconstruction Finance Corporation of the 1930s and 1940s.

Any industrial policy that is formulated would mark a continuation of a long history of a govermnemt role in furthering the economic development of the country instead of relying upon the guidance of an "invisible hand." The U.S. developed economic preeminence with the participation of the federal, state, and local government and periodic modifications of economic institutions through legislation. As it became necessary from time to time to overcome problems and encourage change, there was no laying back and saying we have a free market which will make this come out all right.

Public canals and roads and private railroads and airlines were built with government assistance from the earliest years of the nation. Federal mortgage insurance spurred mass production of housing, and federal rural electrification loans advanced American agriculture. In more recent years, mass transit, water, and sewer systems hae been built and renewed with federal assistance. The budget policies of the Administration are cutting back many of the federal programs that have been assisting state and local governments in the provision of public facilities and in economic development.

Following the Great Depression, during the years 1932-34, there were additional economic and financial institutions created, such as deposit insurance, mortgage insurance, the Federal Home Loan Bank System, and the Reconstruction Finance Corporation (RFC). The latter was an industrial policy program. It not only provided capital to rescue ailing companies, such as the B&O Railroad, it also helped start new firms, such as Reynolds Aluminum, to increase industrial production capacity where needed. The old RFC stopped making loans in 1953 and was completely liquidated in 1957.

In the pre-World War II depression years, the old RFC, in addition to making loans to private businesses between 1935 and 1941, purchased about $700 million in securities from the Federal Emergency Administrator of Public Works which supported public works construction activities that provided jobs in areas of high unemployment. Today, that would be about $7 billion of construction projects, given the rise in construction costs. It, also, aided housing construction, through investments in the RFC Mortgage Company, later to become the Federal National Mortgage Association, which spun off the Government National Mortgage Association. Some $4 billion in loans were disbursed to help private financial institutions survive the Depression.

The largest part of RFC investments was in industries essential for defense and war production; however, the bulk of the loans to private, nondefense business, as well as direct loans made through the RFC mortgage company, was made in the post-World War II period, to help in the industrial reconversion of the economy to a peacetime status. In the approximately 21 years of its active operation, from 1932 to 1953, the RFC either made direct loans and took immediate participation or took deferred participation in business loans. The deferred participations were, in effect, loan guarantees for up to 75, 80, or 90 percent of the principal amount. Loans went to firms in almost every major category of manufacturing, as well as to enterprises in agriculture, forestry, fishing, mining construction, wholesale and retail trade, services, transportation, and utilities.

The operations of the old RFC which continued into 1953 helped to lead the economy out of the Great Depression, to finance wartime defense production and to help in the post-war industrial expansion that supported a long period of economic growth, relative price stability, and prosperity. It also provided a precedent for creation of an institution to help in industrial revitalization when the economy reaches a historic period of blocked growth. Apparently, such conditions have developed in the American economy in recent decades.

The U.S. must maintain its technological leadership, and the AFL-CIO supports legislation like S. 1286 that would contribute to technology development. For the reasons discussed in this testimony, the development of high technology is no longer by itself assurance of a viable manufacturing base. The problems contributing to the decline of American industry should be approached in a comprehensive manner in the context of a reindustrialization policy so the U.S. can realize the full benefit of U.S. technical capability.

Senator GORTON. Thank you very much, Mr. Cunningham.

Mr. Dykes, you offered to show us as an illustration some of the ways in which we are not using the technology we have. I would like you to do that at this point.

Mr. DYKES. I will try to be brief and not too technical. One of the things I want to describe if you will look is this top exhibit. A single axis board refers to a numerical control of an access tool.

This is typical production technology available today, which as I mentioned is only being used currently in about 5 percent of our manufacturing machine operations around the country. This provides now with the use of the microcomputer microchip a computerized control which increases the flexibility of the machine tool, minimizes setup time and in effect increases the throughput rate we can get from a fixed machine investment already sitting on the shop floor.

So just the addition of what we call CNC [computerized numerical control] greatly enhances productivity without a reinvestment in the basic tools themselves. At the same time silicon technology which probably some of you have been exposed to with the microchip revolution that is going on is at the same time impacting the cost and flexibility and functionality of the actual machine tool control system itself.

All of this area in yellow including this inside has now been replaced by one single piece of silicon. Here it is denoted by the yellow code. All of these red dots have been replaced by one red dot equivalent on this board. So we have cost reduced the single axis board by one-third or about $1,000 by putting it all onto one piece of silicon.

At the same time for the same space in the machine which is this area of this board, we have now created three machine controls or three axis controls systems with a full computer interface of the board system itself so we have been able to use modern electronics technology not only to upgrade the machine tool system but the electronics that go with it.

Senator GORTON. The thrust of your testimony is that this is available now but not widely enough utilized.

Mr. DYKES. Correct. Correct, and at the same time technology is moving very rapidly using the silicon revolution to make this technology even more powerful which can be upgraded in the plant.

Senator GORTON. Thank you very much. Senator Heflin.

Senator HEFLIN. Mr. Dykes made a very interesting statement and provided a good picture of GE's strategy for the future. I wish we had more of your 367,000 employees in the State of Alabama.

I also note you are located at Research Triangle Park area of North Carolina. From your experience and observation has Research Triangle Park been successful? Has it aided you? What suggestions would you make relative to future research parks? Are there other things like Government laboratories needed in areas of that sort.

Mr. DYKES. Let me make a rather global answer to that. First of all I think the association with General Electric Co. in the park goes back to 1980 when we made our first decision to locate there.

It has been very successful and the thing I think has made it successful in our minds is the cooperation that has existed day to day between the academic institutions in the area, State government and the industries located in and around the park. There is a great deal of handshaking going on in understanding common problems, working the curriculum of the schools, training professors, the State's investment in facilities near us. That has worked out very well.

On the other hand, that park has been in existence for some 25 years and it is a very slow process. I think it's incorrect to move quickly in the direction of expecting all research parks to move as rapidly as this one appears to be when it is really just rising to the surface and has been going for quite a long time. Our association, though, with the spirit of working with academic institutions, we are also working with MIT, with Stanford, with Rensselaer and similar cooperative programs in terms of sponsored research leading to areas of improvement in the areas of interest to us, in factory automation and microelectronics has been very successful.

Senator GORTON. Senator Lautenberg.

Senator LAUTENBERG. Yes, thank you, Mr. Chairman.

Mr. Dykes, I was interested in a couple of things you had to say. I was curious about one. You said GE has invested $500 million in the last 2 years.

Mr. DYKES. Right.

Senator LAUTENBERG. In new products acquisition and technology. That is not a lot of money if $490 million of it was used for acquisition, and I just wonder what the breakdown of that is. I don't really see the relevance of the acquisition and the investment technology in the same thing.

Mr. DYKES. The context of the remark on the dollars was tied toward productivity enhancements and not those things done in the course of making acquisitions for growing the business. I don't have the breakdown in terms of how much of that was R&D versus acquisition costs, but I would be happy to provide it to you.[1]

Senator LAUTENBERG. OK, because you make the case and I think a very clear one, and I want all of the witnesses to remember I, too, am a sponsor of S. 1286 so the questions are not in opposition but rather in terms of my responsibility in getting the information we need to make decisions about it. You were concerned, I think, rightfully about the targeting, and I was interested in the testimony of Mr. Domnick in terms of how do we get the Government's participation without making the Government either the selector of the winners or just tossing money away when there is a losing proposition.

This is not a bottom line consideration but I am not sure we are talking about the investment here in manufacturing as the emphasis has suggested. In order to help me out, Mr. Dykes, do you know how much of GE's revenues come from the manufacturing side in relatively recent times and how much of it comes from either the credit side or the information side? What is the GE network, the information network?

Mr. DYKES. I don't know. I can't answer that.

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[1] See p. 76.

Senator **Lautenberg**. I am going on something out of my business background. That is not fair. In any event do you have any idea at all how much of GE's new revenues come from manufacturing and how much of it comes from service businesses?

Mr. **Dykes**. I can only tell you we are organized in five large sectors, and the sector I am associated with is the technical systems sector which is all of the areas that are largely manufacturing in terms of military, defense, medical, factory automation. That is about $6 billion.

There are no services in that sector. In addition to that aircraft engines are also a large business, a couple of billion dollars. That is independent of those sectors.

So again I think to be correct for the record I would owe you some correct data, but probably not more than one-half of our business is in manufacturing.

Senator **Lautenberg**. You also said in your comments you made a point about the fact that the technology is there. It is just not appropriately used.

Is that because so much of our business is being done by small business.

The chairman wants to whisper sweet nothings. Do you want to move this along?

Senator **Gorton**. Finish your question.

Senator **Lautenberg**. All right. We will quit while we are ahead with one exception and that is I want to ask Mr. Domnick something.

You encouraged investment in research by the Government. Do you have a view on industrial policy in very short form, national industrial policy? If not, please do not feel compelled.

Mr. **Domnick**. I wouldn't propose to give you that information.

Senator **Lautenberg**. I feel too much pressured by my benevolent chairman here, and I will quit.

Senator **Gorton**. Senator Riegle.

Senator **Riegle**. I would ask a question which I would like you to respond to for the record so let me try to make the question clear and in the interest of time have you give a response in that fashion. I am very much concerned about our competitive position vis-a-vis the rest of the world in the area of technology.

We see all kinds of things that show advances that other nations are making and the whole world economy continues to apply in the way of pressure along those lines. My sense is we need to move faster and we are talking here about some ways to move faster.

I would like all of you to summarize as best you can for the record the jeopardy you see for the United States from these new pressures should we fail to move quickly and efficiently on these various frontiers both in developing technological advances and applying them, in other words, getting them out there in an end use form that both moves ahead the way we do things in this country and enhances our national economic strength and well-being.

So I think it is important for the country to be able to come to terms with what the stakes are here. In other words, if we buy the notion we need to move faster I think we need to understand what the risks are if we do not do that sufficiently.

In other words, what is the loss or damage of foregone opportunity that faces us as a Nation out over the next 5, 10, or 50 years if we do not move as quickly as we can along these lines, and that is what I would like you to try to put in terms that can help us make this case more effectively to people.

Senator GORTON. Senator Riegle asks, I think, one of the most profound questions that can be presented to you. We would ask each of you to think about that and respond in writing.

While you are doing that, I also had an additional question to which I would expect your answers and that has to do with the inhibitions, the walls between the industrial community and the university research committee, the nature of those barriers and how we can improve any legislation with which we are dealing in overcoming those barriers.

Each of you should be an expert, I think, in that subject.

Senator HEFLIN. Mr. Chairman, I would like to suggest the record be kept open so that we might submit written questions.

Senator GORTON. It will be so kept open, and we would like to thank each of you for a very profound and most helpful bit of testimony for us this morning.

S. 1286 proposes to enhance the productivity and competitiveness of U.S. manufacturing industries through research and the application of technological developments. Perhaps the best-known technology is the robot.

The robot can be defined as a computer-controlled device that can be directed to perform a wide variety of tasks and that can reproduce human sensory, manipulative, and self-transport abilities well enough to perform useful work. Our next witness is a robot. He will testify on S. 1286 and demonstrate some of the capabilities and limitations with today's technology.

This is the first time, to our knowledge, that a robot using his own electronically generated voice has testified before a committee of the U.S. Congress. I believe his testimony and performance will underscore the need for and benefits of the research that would be performed under S. 1286.

I would like my colleague and cosponsor of S. 1286 to join me in introducing the robot since the robot is a constituent of his from Michigan. Senator Riegle.

Senator RIEGLE. Thank you, Mr. Chairman. This really is a first here in this Senate and in the Congress, and I want to begin by just saying in passing to you, Senator Gorton, how appreciative I think not only am I but others in this Senate and across the country for your leadership in this area.

Your timely efforts to move ahead on this subject are, I think, a very important contribution to the Nation. The next witness is, in fact, a constituent of mine from Michigan and is a robot made by the Heath Co. located in Benton Harbor, Mich.

This company is a subsidiary of the Zenith Corp. The robot you will be meeting will bear some similarity to others you have seen. Probably everyone here has seen "Star Wars" and remembers R2D2 for his terrific work in the course of all three movies that came off the particular "Star Wars" series.

In any event HERO, the person or robot that you are about to see today, derives his name from Heath experimental robot is where the letters come from that spell the name "HERO." He is being marketed as a retraining and educational tool in the sense that the company wants people who want a familiarity with robot technology and the methodology by which they are put together and work to have the chance to learn that in a firsthand way.

So this particular robot can be purchased and either assembled by the person buying it, or it can be bought and assembled for them. While he is limited by size and simplicity, he has all of the main concepts of complex industrial robots.

He can be programed for various difficult tasks. By taking him through a task, he can actually learn what to do. In other words, he can memorize what it is that he is made to do and then he can in turn do it by himself. He has a manipulator arm—this is a one-armed robot—to perform tasks as you will shortly see.

In addition, he can sense motion, light, and sound, can speak with a virtually limitless vocabulary based on 64 different sound groups, each less than one millisecond long. He can move his arm, his wrist, and his hand grips as you will shortly see.

I might say before December of last year a robot which could be purchased and assembled by someone would have cost in the range of $150,000. HERO who you are about to meet costs only $1,500 unassembled and good luck with the instructions—or $2,500 assembled. I am told that an inexperienced builder can assemble HERO in about 80 hours, and an experienced builder can do it in about 40 hours. He weighs 39 pounds. He is 20 inches high and has as I mentioned to you one arm.

I might just say to you finally that Jim Lytle is here along with HERO and representing the company and while no one person can take the credit for inventing this particular robot, Jim Lytle headed the project and he has programed HERO for this hearing and will be commanding him. I might finally say this particular robot is being marketed as a self-learning robotics program.

By using the educational book and the building and working techniques that come with it, a person can learn the fundamental principles of robotic technology. With that, let us welcome HERO to the committee room.

VOICE. Mr. Chairman, with your permission we would like to have HERO deliver his testimony.

Senator GORTON. You have the committee's permission.

STATEMENTS OF DR. RUSSELL DREW, CHAIRMAN, GOVERNMENT ACTIVITIES COUNCIL, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS; JIM LYTLE, CHIEF DEVELOPMENT ENGINEER, HERO; AND HERO-1

HERO-1. Good morning, Mr. Chairman. My name is HERO-1, the Heathkit education robot. I am here with the IEEE to speak on behalf of robotics.

I am a programable device that can do many things. I will do them over and over again without becoming tired or irritable. I have a memory and sensors that help me perform my assigned tasks.

I have many of the same capabilities as my larger industrial brothers. We can work well with humans, but we have limits. We need better sensors, mechanical systems, and user friendly software.

We can serve you better with better technology. We need your help to become more useful.

Mr. Chairman, I join the IEEE in supporting S. 1286, the Manufacturing Sciences and Technology R&D Act of 1983. Thank you very much.[1]

Senator GORTON. The committee will join me to receive a copy of this statement.

We thank you, and we thank HERO-1.

Senator HEFLIN. Can I shake hands with him?

Senator LAUTENBERG. No. Shake hands with the ventriloquist back here.

Senator GORTON. We will now call up our next witness. HERO-1 is accompanied by Dr. Russell Drew, representing the Institute of Electrical and Electronics Engineers.

And perhaps, Dr. Drew, for both the benefit of the committee and the press here, you would demonstrate some of HERO's other capabilities?

Dr. DREW. All right, Mr. Chairman. I have also with me, as was pointed out earlier by Senator Riegle, a fellow IEEE member, I am proud to say, Jim Lytle, who was the chief development engineer for HERO. And I think it would be best if Jim, as the mastermind behind this system, took over for this phase of the testimony.

Senator GORTON. We are delighted to have Mr. Lytle with us.

Mr. LYTLE. Thank you.

If I may, let me just turn the robot around so I have access to its keyboard.

As HERO was introduced, it was mentioned he has a number of sensing devices. We designed HERO to be self-sufficient. He has his own onboard computer, his brain so to speak. And using the various sensors that he has, he is able to make decisions on the basis of things that happen in his environment. He is a truly intelligent robot.

Let me begin by running a little demonstration program that I have to show some of his capabilities. As you have already heard, HERO can speak. He has an electrically synthesized voice, the only sounds he can make. He speaks much like we do. He takes basic sounds and strings them together to make words. For example, the noises HERO can make are these.

[Demonstration.]

Those are the only noises he can make, but under control of his microprocessor brain, he strings them together, inserts appropriate pauses and whatever, and can speak an unlimited vocabulary in any language.

HERO-1. Ready. Parlez-vous français?

Mr. LYTLE. He speaks French about as well as his programer does. Spanish.

HERO-1. Habla espanol?

Mr. LYTLE. As I mentioned, an unlimited vocabulary.

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[1] The above testimony, prepared by Dr. Russell C. Drew, Chairman of the IEEE United States Activities Board Government Activities Council, was entered into HERO 1 with the aid of a computer. It consists of almost 1,000 bytes of information.

Another factor we decided to design into HERO was a sense of timing. Much like humans do he can measure the passage of time. However, he does so very, very precisely. He always knows what the time is and what the date is. You can program him to perform some particular activity at a preset time.

Now I will just ask HERO to tell us what time.

HERO-1. Ten hours, 13 minutes, 35 seconds.

Mr. LYTLE. That is pretty close. In addition to being able to tell the time and use a synthesized voice, he can change the instantaneous pitch of his voice, again as we do, to convey additional meaning or to sing. HERO can sing.

HERO-1. La la la la, la la la, la la la la la.

Mr. LYTLE. So using his clock you could program him up to a year in advance to remember your birthday, for example.

HERO-1. Happy birthday to you, happy birthday to you, happy birthday dear la la la, happy birthday to you.

Mr. LYTLE. Another important sensor HERO has is an ultrasonic ranging system. Using this he can see obstacles, and if he is properly programed take corrective action to avoid them.

Now, when he walked in here this morning he was not using his sonar. I had preprogramed him to travel over that specific path. Had someone put a chair in the way, he would not have been able to avoid it because I did not program his sonar. However, I could have.

Let me demonstrate the sonar by showing you a demonstration routine whereby HERO will tell me when I am precisely 20 inches from the front of his faceplate there. I will turn him on, and if I am closer than 20 inches, he will tell me I am too close. If I am further away, he will tell me I am too far. And if I am right on, he will say you are right on.

HERO-1. Too far, too far. Too close, too close. Too far. Too close. Too close. Too close. Too close. Too close. Too far. Ready.

Mr. LYTLE. So his sonar enables him to measure with a high degree of precision the distance to an obstacle. As I say, it would only be a simple matter to program him to avoid obstacles once he has seen them. He can turn his head to the left and right, look for a clear path, and proceed in that direction.

Those are just a few of the sensors HERO has. As was mentioned in the introduction, we designed him to be an educational robot. In many respects he is far more sophisticated than industrial robots which are used today. We intended him to be a training device, a teaching aid to teach people how the robots of tomorrow will function.

So let me just close by showing one more thing in terms of how you program his movement. This is very, very important, especially in the industrial robotic setting.

Let me show you how simple this is. This device I am plugging in we call a teaching pendant, and as I mentioned, many industrial robots are programed in this manner. It takes very little skill or experience for an operator using a device like this to program a very complex motion into an industrial robot much like HERO is.

Let me put HERO in what we call the learn mode right now. Now, once he is in this mode, he is constantly monitoring the position of the switches on this teaching pendant. What I can do manually is drive him back and forth like this and perhaps turn his head to the right like that, to the left in this manner. I can program more than 1,000 individual steps just like this. HERO all the while will remember each and every one of the steps.

HERO. Ready.

Mr. LYTLE. And no matter how complex the series is, he will remember and execute it perfectly.

HERO. Ready.

Mr. LYTLE. I will play back the simple, short routine I put in here just now. Back a little bit, pause, forward a little bit, turn the head back and forth. It is basically a very simple representation of how a very complex task could be programed into this robot or an industrial robot.

HERO. Ready.

Mr. LYTLE. That is pretty much our HERO-1.

Senator GORTON. Thank you very much. We appreciate that demonstration.

We would now like, Dr. Drew, to ask you or both of you a few questions which will take us into the future.

I think most significantly I would like you to give me your insight into what you consider the relative roles of the Federal Government, industry and the university or academic community to be in conducting research and speeding the application of robots on the part of industry.

Dr. DREW. Thank you, Mr. Chairman.

I would like to preface my answer to that question by pointing out that I am here as a representative of the Institute of Electrical and Electronics Engineers. The IEEE, which is the world's largest technical professional society with over 185,000 members in the United States and over 230,000 members worldwide, is a society which is very closely related to the electronics and computer and software revolution which underlies the manufacturing technology revolution you are trying to bring about.

So we have a special interest in this technology and the way it is advanced, and the question you have asked, which is the appropriate role for the Federal Government in doing that. I have previously been in Government in the office of the President's Science Adviser for a number of years, and I am quite well acquainted with the questions and debate which go on about this question and the type of balancing that has to go on between a very strong and vital economy, which in the ultimate analysis will be the strongest driver for any technological revolution, and the additional impetus that can be provided at critical times in those technological revolutions that have occurred and are occurring which are due to government support at the right places at the right time.

In your bill that is being proposed here, you focused on several key areas, and I want to support on behalf of the IEEE the basic objectives of the legislation here, S. 1286. You have addressed basic research as an underlying support base for this manufacturing technology, and I think in recent years the Federal role, the appropriateness of the Federal role in supporting basic research has basically been accepted by all segments. It tends to be sort of unexceptionable. Actually, I do not think that is the critical place in your bill for support.

So we certainly would not object to this additional basic research support. I think it can be a useful and important addition, but it needs to be coupled with the other parts of the bill which I think deserve additional emphasis.

We are in an era when the Federal Government from some quarters is being asked to step back from several roles it has played in the past with the point that the marketplace provides all of the necessary forces for the introduction of these new technologies. That is true to an extent. However, there are levels of risk and investment decisions which in fact can only be made by an external resource like the Federal Government.

I think in the kind of technological centers you have proposed you have hit upon the bridging role which the Federal Government and only the Federal Government can play. Similarly, the evaluation functions on the experimental program which you have included, which deals with the human impact and interface of the introduction of these technologies, is extremely important; in fact, so important we believe it should receive additional financial support and additional emphasis in your bill as contrasted, say, to the basic research role.

Senator **Gorton**. That leads me to another question. I believe you heard the previous panel.

Dr. **Drew**. Yes, sir.

Senator **Gorton**. Did you hear Mr. Dykes emphasize, I think, what you have emphasized: That to a certain extent what we need is a more widespread use of the knowledge and technology which we already have available? That what is needed in that respect is to increase the actual usefulness in our economy of robots, for example?

Dr. **Drew**. At the present time, it was pointed out, one of the fundamental problems is the investment base, the investment decisions that have to be made in an industrial setting for the introduction of this equipment.

The problem right now as a matter of fact is related to externalities, if you will, things like the interest rates. In many cases you find that the payback requirements established by management are so short that the person who is close to the production line cannot justify in many cases these equipments because of the return on investment requirements superimposed by upper management. These again are a product of externalities. We have to establish a sort of tax investment and interest rate climate in which these new investments to improve productivity can be made.

You said we have adequate technology. I do not want to leave you with a feeling that we believe there is adequate technology. There are important improvements in technology that need to be made. Some of these will be made in the normal sort of the commercialization drive that you see in General Electric's and Westinghouse's efforts. Westinghouse has just purchased recently a major contributor to the robotic scene, and a certain level of technology introduction will occur because of the regular commercial forces.

There are other technologies, however. For example, HERO was brought here today for a very specific purpose. He was here to demonstrate the power of some of these technologies, but also their limitations. The mechanical gripper that HERO has is illustrative of a problem generally, and that is integrating the mechanical systems, reducing their cost, improving the precision of movement and their coupling to sensors. Improving the sensors' role in a robotic system is an important task which is just now beginning to be tackled by the laboratories and the advanced technology services in our Nation.

Mobility—he rolls around on three wheels. The wheel is a marvelous invention, but it has limitations. He does not climb stairs. He has distinct mobility limitations. Mobility is a serious problem in many robotic systems. But for some systems it is not terribly important and so on.

We have a standard-setting role which needs to be played and helped and orchestrated by Government, I think, which will enable the integration of larger remotely controlled, automated, computer-aided manufacturing systems. This integration is at a very primitive stage at this point and will be assisted by a much stronger standards effort.

We could go on. There are tremendous technical challenges here, as well as the challenge of the utilization of existing technology. Both need to go forward.

Senator GORTON. Thank you.

Senator Heflin.

Senator HEFLIN. The Institute of Electrical and Electronics Engineers has a program in which there are congressional fellows involved, and I happen to have one in my office, Mr. Doyce Satterfield, who is behind me.

Mr. Satterfield, you stand up there.

He is from Huntsville, Ala., and has been working with the ballistic defense missile program there. He is formerly with NASA.

So I think your program of providing congressional fellows is an excellent one, and we are pleased that Mr. Satterfield is in our office.

There are a lot of problems, of course, in dealing with robots, and this one you have here is an ingenious one that can be adapted for many purposes. Do you see a role for robots in basic research? And if so, how could a robot aid in basic research?

Dr. DREW. Mr. Heflin, robots have aided in basic research. I guess the space program is probably the principal example of how systems which are really robotic in character have operated very, very successfully as an integral part of the basic research system, and in fact, they illustrate an important role for such robots; that is, in hostile environments, in places where it is not easy to send men. They are an absolutely vital part of the space program, have been, and will continue to be.

Many of the basic research activities, however, are in universities, as a teaching tool as well as a device for exploring and expanding our knowledge base. The human involvement there is just going to be really very important, so I do not think, as a matter of fact, even if they could substitute that you would want them to, because the learning experience is too valuable for a human.

There are other places, however; for example, places where there are hazardous environments, in the case of a hot cell in nuclear systems research, those sorts of things. Hardened robotic systems which in fact can operate in those environments will aid immeasurably, I think, in basic research. So I see that kind of role.

Senator **Heflin**. Well, now, in exceptional hazardous conditions would there have been a role or could there be a role in the future where you might have some type of a meltdown in a nuclear plant like in Three Mile Island or some problems that were to arise there? Can you envision a scenario of how a robot might be useful in such an extra hazardous atmosphere?

Dr. **Drew**. Absolutely, Senator Heflin. As a matter of fact, if we had had suitably hardened robots in the Three Mile Island circumstance, we would have had much better firsthand information. I mean the human eye aided by a remote device that can provide visual information can be tremendously helpful to try to interpret the results that your other instruments are giving you, and I think that is an important application. We need to do more.

As I pointed out in my testimony, I can see a role in a number of public service applications. If I might just mention two of them, that is, police and fire applications for remotely controlled robotic-type devices. It seems a terrible thing to have to, for example, use firemen, humans, and force them to make the agonizing decision of entering a burning building with the prospect of saving someone perhaps not knowing whether they are there or are savable and risking their own life, when if we had a remotely controlled robotic device, suitably hardened with sensors that could penetrate smoke and see in that environment, and perhaps a little cocoon in which you could bring a rescued person out. You know, I would foresee every major fire department having several of these for special circumstances to augment the regular fire department applications.

Similarly, in police applications, when you have every week essentially in our modern society an occasion where you have someone shooting at anyone who moves and you are subjecting police officers now to this terrible decision about inundating that location with fire or risking the life of a policeman in rushing in and trying to subdue such a person, a robotic device, again suitably prepared and remotely controlled, might operate in that environment extremely well. But we need improvements in the technology, and I think that is an important lesson.

Senator **Heflin**. Could you foresee another example—and I do not want to go into a lot of examples—but one example that comes to mind is in coal mines, some type of underground mining in which you have gases that make it extremely hazardous for humans.

Is that another example in which they could have roles?

Dr. **Drew**. Yes, Senator Heflin. There is an important question here, and it has to do with the cost of these systems. At the present time the kinds of capabilities that we need for such applications tend to make the unit itself extremely costly, so there is a reluctance in the tradeoff here to make the investments. Economically it is not as attractive to make such investments, so we do not use robots as often we might in such situations.

Undersea application is a clear example of another area where we are using robotic devices in hazardous locations. Here, oil exploration provides the capital base which allows companies to make the large initial investments in these systems.

Senator **Heflin**. We are looking at legislation that Senator Gorton has taken the lead on, and we have been supportive of it, relative to the role of Government in developing new technologies and new approaches. The role of Government in the development of robotic science, robotic productivity, is something I am sure we want to address and is really the real purpose of this hearing to date.

Do you foresee that there will develop by industry or individuals some type of need for a bringing together through joint ventures or participation by Government relative to the research of robotic science?

Dr. **Drew**. Senator Heflin, I would like to reiterate my support for a Government role in this area. I would also like to raise a question.

I believe this legislation should clearly spell out a restriction from getting into areas where you get close to commercial product lines and commercial introduction. Government historically has been very poor in making those kinds of decisions, and I think it would be improper to suggest that that is at all the intent or the extent of this type of technology utilization activity. But providing assistance, for example, in the small business arena can be extremely valuable.

There are other Government provisions which I think are adequate today to allow collaborative adventures. The R&D limited partnership, for example, is an extremely valuable resource and device. I think Dr. Merrifield in Commerce is doing a very valuable task in getting information out about the extent and utilization of that type of arrangement. And I think the role here should be to help the private sector operate in a way in which it can operate best rather than to interfere with it.

So it is a light hand on the throttle, if you will, but it is not no hand on the throttle. I think the Government needs to be there with an appropriate role. I think you have about the right kind of role in your bill.

Senator **Heflin**. We hear the word "robots," and I think naturally there crops up into the minds of most people in America does this mean job displacement for human beings. This is something we hear frequently. In trying to push for increased productivity, increased competitiveness, there is that problem that could exist.

Do you have any thoughts as to the future relative to human job displacements?

Dr. **Drew**. Well, Senator, I would hate to really look too deeply into a crystal ball on this one. No. 1, let me make the following point. I think it is terribly important that your bill include some attention to this problem. Any time we have a technological revolution—and this is how I would like to characterize what is happening here—you do have displacements and dislocations.

And in the short term, yes, I think you will have job displacement. We have had job displacements before. We went from the horse and the mule to the tractor.

Senator **Heflin**. Well, we had the wheel. The wheel obviously brought that about. That probably displaced more humans on pushing or on the other hand animals that pulled.

Senator **Riegle**. But not all of us remember that like you do.

Senator **Heflin**. Some of us are students of history.

Dr. **Drew**. We have managed to surmount this in different ways. I mean our grandfathers worked 6 days a week, maybe 7, or 6½ days a week, I am told, although if you are in small business, as I am, or in Government, as you are, the idea of a 35-hour work week is something like pie in the sky. We do not recognize that, but that is a kind of average workweek in the United States today.

Senator **Heflin**. We have got the Friday afternoon clockwatchers and the Monday morning clockwatchers, too, so it works about like that.

Dr. **Drew**. So we find other ways to accommodate to these types of changes and revolutions. And I am positive in the long term. I am concerned about the short- and mid-term effects, and I think that is an important role for this legislation. In fact, I think it is one of the key emphases.

Senator **Heflin**. Do you foresee that there is some need for a think tank relative to this?

Dr. **Drew**. I am reluctant to use that in the singular. I am a great believer in diversity.

Senator **Heflin**. I mean think tanks. I do not necessarily mean just one.

Dr. **Drew**. Yes, I think there should be some support given to building some sort of coherent capabilities to deal with this issue. I would hate to use it in too narrow a term. I think it needs to be coupled with the technology and its utilization.

Senator **Heflin**. Thank you.

Senator **Gorton**. Senator Lautenberg.

Senator **Lautenberg**. Thank you, Mr. Chairman.

I was very interested in your comments, Dr. Drew, about the adjustment you said to technological revolution that we have made in the past. I think we have made those adjustments very well, but this one is different, I think, and I wonder whether you agree, because this one for the first time takes over, as we have seen with our friend over here, this one takes over perhaps some of the thought process.

We are now dealing with a work force, which I am sure you know, is largely information-oriented or information-based, whether we talk about anything from a secretarial job to a sales job to a researcher. So much of our work force is in the white collar sector. And now we see competition in those jobs, simple enough, word processors, the ability to store information and call on it when you need it as opposed to the human intervention it ordinarily had.

I am very much concerned about this topic Senator Heflin brought up, and that is, are we really facing up to the problems of worker displacement, and do you think there is enough awareness of the changes that might be brought on by this new phase of the technological revolution or development? I do not think so, but I would like to hear what you have to say.

Dr. **Drew**. Senator, I would agree with you. That is why we felt it would be necessary to emphasize in our comments about your proposed legislation that element, the human impact. You are talking about not only a technological revolution but a consequent sociorevolution that takes place. And it is very clear now that—you mentioned word processing. There are a group of people—let us call them secretaries or what have you—that used to have to spell, and now we have in the word processing systems spelling dictionaries that will automatically check the text and correct the spelling or at least identify places where correction is needed. We certainly know intimately the problem. We used to have to add, subtract, multiply, divide, and maybe do manual square roots or things of that nature, and now we all do it with our pocket calculators.

So there is a change, and the question is is that worse for society or better. And at this point I would hope that your legislation would emphasize building an information base. How one makes choices on that and deals with it is a bigger problem than I am prepared to discuss at this time.

Senator **Lautenberg**. I think again we have to face up to it. It is easy to talk about the retraining of workers displaced by a change in the manufacturing complex, and I think it is important that we convey to the working people of America that one need not be an engineer or a physicist or a scientist to interface with technology. There are many jobs which are relatively basic jobs in which you use new equipment and the electronic systems. But as we look now at this next phase, I think we see something which we have not as yet dealt with, and I hope we will be able to pay enough attention to it here.

One of the things we heard talked about this morning by the other witnesses is a very serious interest in having government intervention, government financing, of some of the basic research that takes place in our society. On the other hand, as you know, there is a continuing debate about when government is interfering too much. Do we want ourselves to be in a controlled society? It has to do with the development or review of a national industrial policy. How do we make certain that government stops at the point it should and lets the free enterprise or the entrepreneur or the business community take over its responsibility?

Dr. **Drew**. Senator, I would like to move to a provision of your bill that is an important resource in that regard. You have structured in the bill an advisory committee. Listen to that committee. You on the Hill will be listening to that committee or should be. You are listening to your constituents.

I think the executive branch also needs to have that ear open to the community because on the day-to-day management of the programs, that is where the responsibility lies. So I see that as an important adjunct of what you are proposing to do here.

The advisory committee, I believe, as a matter of fact, should broaden its constituency to include a small business element. I am also a small businessman. We are in the process of working and developing a new technology which will involve manufacturing on a small scale. We definitely do not want the government in that portion of our business, and I am going to speak out, and I am going to make those views known very strongly. So I think those mechanisms—as long as in our society we keep our channels of communication open and you are listening to us—we will be able to begin to find out where that boundary is between government and the private sector.

Senator **Lautenberg**. The problem is sometimes you listen to a voice louder than another, and it is very hard to sort out what the right thing to do is. It was of interest to me and I know to Senator Riegle that as we sat here this morning, the camera equipment that was all around us carried names like Sony and Hitachi and such. It is distressing to see that America has lost so much of that opportunity, and it makes the situation particularly poignant as we sit here and talk about this.

I just wondered with your colleague there, Mr. Eaton, whether HERO-1 does housecleaning as well. If it does, I can see a terrific use for it, and I can imagine the husband asking the wife the question: Who is that robot I saw you with yesterday?

Thank you very much.

Senator GORTON. Senator Riegle.

Senator RIEGLE. Thank you, Mr. Chairman.

First, let me just ask about the software for HERO. The unassembled price for this robot is $1,500. The assembled price is $2,500.

Mr. LYTLE. That is correct.

Senator RIEGLE. So it has been reduced an enormous order of magnitude from the last generation of robots of this sort just within a 12-month period, so we are seeing a tremendous sort of learning curve in terms of application of technique and reduction of cost.

What is the software cost for this and what software comes with it?

Mr. LYTLE. The software that comes with it is inherent in the machine. It is a basic part. It is a permanent part of its memory. The software enables you to teach the robot, as I demonstrated earlier. It enables you to drive it around with the teaching pendant and perform some tasks with the arm. This is all in the onboard software. It takes care of the utility routines. That makes it possible to store that in its memory.

Senator RIEGLE. To get it to the point where it can speak in other languages, what is involved in that?

Mr. LYTLE. That is relatively simple also. We furnish a little dictionary we call it. It has basic English in it. There are about 800 words, and supposedly you can express any concept, however abstract, maybe a little awkwardly with these 800 words that are in here.

Senator RIEGLE. Give me that book, please.

Mr. LYTLE. Some people might be tempted to try some words that are not in the dictionary.

In order to do that, we have the list of sounds in the back, the basic sounds, and an example of how they are used. You can program any word, a pet name, that sort of thing just using the information in the documentation.

Senator RIEGLE. So in order to take this machine and make it usable, you do not need a whole raft of additional software packages.

Mr. LYTLE. Not at all. It is self-contained. That was one of the design objectives, to make this machine usable from the very beginning by a novice who can use this device here to program it. And yet, we like to believe even after years of experience there will still be the challenge to try to make it behave in a little more sophisticated manner, to utilize your ingenuity to make HERO smarter, to react more humanlike.

Senator RIEGLE. It is remarkable to me that we have gone from robots that would cost $150,000 to a robot here on the table that costs $1,500.

Mr. LYTLE. In all fairness, I should point out while we embody the basic technology, the basic principles are the same as these robots you describe. However, the degree in precision is far different, and this is where the costs rise exponentially. If you improve the resolution of the manipulator, for example, you double that; you might quadruple the cost. And, of course, the weight-handling capability, the speed, these are all factors that make the industrial robot really a different machine in terms of how they operate but not in basic principle.

Senator RIEGLE. I understand. I would like to ask both of you to respond to the earlier question I posed to the last panel; namely, what you see from your respective vantage points as the jeopardies and risks that seem to face us if we do not move forward as quickly and well as we can along this whole frontier.

My sense is with the nature of the world having changed the way it has, we face quite a different circumstance in dealing with this particular revolution and maybe others we have faced previously. And when Senator Lautenberg made the comment about the human factor, about which I also have a real concern, the whole displacement issue and trying to understand what that means not just in sort of an industrial work setting but in a white-collar setting, the changes and functions that are being taken on, cost accounting machines, a lot of other things that seem to be altering the nature of work in terms of what parts machines do and what part is left for people to do. So I think that is a key issue and the one that we really have to examine carefully here.

I just might note as an aside one of the things we are talking about now with education which has become a major issue in the country is we are talking about "a return to basics." I think in a sense we are all kind of attracted to that notion initially—reading, writing, arithmetic. And then I sit here listening to you talk about machines that are self-correcting in terms of words typed on a piece of paper. We have obviously seen in mathematical functions where machines have moved in and displaced hundreds of thousands, millions of people who used to do mathematical-type work.

So I am not quite sure we have managed to connect these things up. We may find ourselves going down one track in terms of technological development and quite a different track in terms of educational goals. That is a matter of some concern to me, to make sure that in the end we end up closing the loop, so we are really harnessing ourselves as a nation in a common direction, if you will, at least in some strategic sense.

But the point I want to get to is this. It seems to me with the world competition picture we are facing today and the speed of technological transfer, some of the differences in cost structures around the world where you now have other countries fully in the ballgame—you have Japan in, in many areas even in the lead in terms of some of their techniques and products and processes and so forth.

But you have in sort of a second tier nations like Korea, Taiwan, Singapore and other places coming along at an incredible rate of speed showing an ability to adapt and move very quickly on a number of these things.

Societies are different. Different arrangements exist within those societies to help move some of these things forward. But it seems to me the whole assimilation process of a revolution under way—and I think we are in the midst of a fullblown revolution here—this one is occurring in a changed world picture, in a world picture that is fundamentally altered and different from what we have experienced in previous times. And I think as a result, the difficulty of making the adjustment is far more severe for us than perhaps we imagine it is.

I think there is always a tendency to live off our historical experiences and to assume because we may have done something 25 years ago or 50 years ago rather readily in adjusting that we can somehow do the same thing here. It seems to me the nature of the adjustment process here is much more difficult, and we are doing it in a world economic, technical and structural framework that is not like anything we have had to deal with before.

I think it reduces our margin for error. I think it means we have to move faster than we are accustomed to moving. I think the normal pace of change here, which was sufficient in a less competitive world environment, may not be sufficient today, and we may have to find a way to speed up our capacity to adjust, adapt and work these problems out, not only in terms of the speed of the technological advances where I think we have got to move faster. I think it involves facilitating certain sorts of consortium efforts both in the private sector, maybe taking down some of the barriers that constrain that, as well as finding a way to effect a better partnership between government and business and with labor very much a part of that in sort of a three-part arrangement.

It seems to me that the necessity to do that complicates this task enormously. I do not know it is sufficient for us to assume that somehow or another if we all just step back it will all sort itself out very nicely in a way that is good for the United States as an entity in the end, and that is where my concern lies today.

So I am very hopeful that with the leadership such as the Senator from Washington is showing here in bringing these issues to the fore and giving us a chance to try to dig down beneath the surface into the crosscurrents which are at work here to try to make some sense of them, this is, I think, exactly what must be done. But we are, I think, some distance away from the answers we need to find.

I will say only one more word on worker displacement, and that is, it is within the structure of our economy today—and I happen to come from a State that is hard hit in terms of the structural impact of some of these economic and technical changes—and we are finding even with a very accomplished work force and a very accomplished business sector we can end up with residual unemployment in the range of 15 percent of our work force in the State, the eighth largest State, and that we can find ourselves in that condition for a three-year period with unemployment above 10 percent for that entire period of time and likely to continue at that.

We are not seeing the mechanisms by which this problem is self-solving. It is not. If there is one lesson that is clear right now, it is that it is not self-solving, and we should not need a lot more data to understand that. So how we facilitate these transitions, how we handle people problems in the meantime, they are extraordinarily important, directly related issues.

We had a vote on the Senate floor in the last 2 days on mortgage assistance for unemployed workers, and these are workers who have been, in many cases, good workers with a work history of 10, 20, 30 years. They are now displaced, partly by world competitive pressures as well as domestic ones. Their jobs disappear. There are no new jobs to take their place. They exhaust their savings and their unemployment benefits, and they are now in the process of losing their homes.

Here we are focused on an issue to try to provide emergency mortgage assistance on the theory that a displaced worker ought to be able to hold their home until such time that they get geared back into the work system.

So it seems to me if we do not connect all of these pieces and come right back down to what the human dimension is for people in the United States and in the end having some clear sense that what we are doing in a composite sense is sound—sound for the Nation, sound for our people, sound economically, sound with respect to the world competitive pressure, sound with respect to our other obligations we take on, free world defense and so forth—that we are not going to be able to have any sense of certainty that we are not just working ourselves deeper into some problems for which we do not presently have answers.

So I would hope as we go down this road that we could find a way to try to integrate an assessment of and some kind of response to the key component elements of this and sort of work it into a whole. It is not even easy to say, but if you do not say it, it does not get conceptualized on that scale. It seems to me that is what in the end we will have to do here.

Senator GORTON. Thank you. Thank you, Dr. Drew, Mr. Lytle, HERO-1. We very much appreciate having had you here.

Dr. DREW. Thank you, Mr. Chairman.

With your approval, I would like to have my written statement entered in the record.

Senator GORTON. It will be entered into the record in full, and to the extent you have answers, more detailed answers to the questions which have been presented here, we would appreciate having them in writing.

Dr. DREW. I would be glad to do that.

Senator GORTON. I take it HERO has a final statement.

HERO: Thank you, Senator Gorton, Senator Heflin, Senator Riegle and Senator Lautenberg.

Senator GORTON. Thank you.

[The statement follows:]

STATEMENT OF DR. RUSSELL C. DREW, UNITED STATES ACTIVITIES BOARD, THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.

Mr. Chairman: I appreciate this opportunity to testify today on S. 1286, a Bill to initiate a program of research and development on manufacturing sciences and technology and to evaluate the industrial setting in which these technologies are applied. I am here as a representative of the Institute of Electrical and Electronics Engineers (IEEE), the largest technical professional society in the world, with over

185,000 members in the United States, and more than 230,000 members world-wide. I am the Chairman of the Government Activities Council of the United States Activities Board of the IEEE, which is particularly interested in bringing the expertise represented by the various disciplines in the Institute to bear upon public policy issues in an effective and timely way. I also have a long-standing personal interest in the topic before you today.

We in the IEEE have a special interest in the areas being addressed by this proposed legislation, since our members work actively in many of the technologies that will support advances in manufacturing such as computers, integrated circuits and other sophisticated electronics, and software developments and artificial intelligence work. Simply stated, it is our work that has made the revolution in manufacturing technologies possible.

We strongly support the objectives of S. 1286. Government has played a valuable role in bringing us to the threshold of the revolution that is beginning to take place, and it can and should continue to take a highly focussed and supportive role as we enter a new era in manufacturing.

The areas of support identified in the proposed bill respond to current needs, that is, they provide support for fundamental new knowledge to underlie further advances in the field, cooperative funding for more applied work which precedes commercialization, and experimental activities which focus on the human dimension or human impact of increased automation. These elements are appropriately backed up by an evaluative function and an external advisory committee. Together, these elements provide a valuable addition to efforts that already exist elsewhere in Government. I should note that there is an important difference between this program and other Federal efforts that is absolutely critical to its success. That is the attention to the human impact aspects and the detailed competitiveness evaluations of impacted sectors or areas of high opportunity.

As we have seen today, it is very easy to be impressed by the capabilities of robotic systems. Their potential is truly remarkable and I believe personally that they will become a part of our everyday life just like the automobile and the television set. In the workplace they are already making inroads, particularly in hazardous or unpleasant jobs. But we are only beginning to see and understand the range and diversity of their application and the resulting impacts they will have.

For example, my favorite personal vision is the use of such systems, preferably remotely-controlled by a human operator, in public service occupations such as police and fire fighting. A robotic fire-fighter could enter a burning building and with appropriate sensors, detect and fight the fire at the actual combustion sites or rescue victims—perhaps in a protective cocoon—without risking the life of a human fireman. Similarly, a remotely-controlled policeman could be used in the frequent circumstance where a desperate person shoots at everything in sight, without risking the lives of the usual SWAT team or engaging in the fire-fights that often result. The prospects for robotic devices are both intriguing and exciting, but such devices will need to be brought into being with care and with attention to the larger systems in which they are to be a part. In this proposed legislation there is an opportunity to address these questions.

There are a few specific suggestions that I would like to offer as additional points to consider in refining its content.

First, the funds authorized under each of the major program elements. Following the emphasis of my earlier remarks, there appears to be insufficient authorization for both the competitiveness studies and the research utilization program. Each of these elements could be doubled from their current modest levels. In addition, the funding for cooperative agreements could be increased in the first and second year to $10 million and $20 million, respectively, and the guidance to the program managers include endorsement of multiple year commitments of sufficient size to create a critical mass of effort at the Centers for Manufacturing Research and Technology Utilization suported by such cooperative agreements.

Second, the organizational structure for management of this program. It is wise at this particular time, when significant attention is being given to the reorganization and re-chartering of the Department of Commerce, not to be too specific about such matters. If the Department becomes a Department of International Trade and Industry, and its major technical elements are split off to other places, perhaps to a new entity which would focus on applied technology, this program would quite likely move and its management structure would have to respond to the new setting. It should be emphasized that wherever this program is placed, it will need a competent and adequately-sized staff. There is little of the needed expertise that is not already otherwise committed in the Department currently, so provisions must be made for building the necessary capabilities and for their placement in the departmental structure. This program might be appended to Dr. Merrifield's Office of Productivity, Technology and Innovation, for example, but only if there were additional staff positions added.

Third, the small business aspect of manufacturing technology needs to be explicitly recognized. A major fraction of the value of manufactured goods in the U.S. is produced in batch processes and many of the producers are small businesses. These businesses rarely have the resources to do R & D on improved manufacturing technologies and would profit from attention in this Bill. Small business has also played a strong role in the development of robotic devices, and generally provides a major source of new jobs in the economy. Among other things, the legislation should include small business representation on the Advisory Committee and members of this committee should be able to be compensated at the current maximum daily Government rate, so as not to exclude participation from either small business or university authorities on simply financial grounds. Similarly, patents that result from this research should be subject to the same assignment of exclusive rights as is specified elsewhere in recent legislation.

Finally, it should be recognized that there are many other important aspects of a national effort to improve the competitiveness of U.S. manufacturing. These include efforts to expand the attention given in our educational system to topics relevant to manufacturing, considering it as a whole, and dealing with improved techniques for each phase of the process and not just robotic devices. A particularly important area is standards development. Standardization can be key to producing integrated systems since it will make possible modular approaches and simplified interfacing of components from different sources. A strong standards-development effort is an important companion to this legislation and the efforts at the National Bureau of Standards need to be given additional funding support. The voluntary standards efforts of industry and the professional community also should be given encouragement and perhaps broader guidance from Government sources.

The improvement of a large body of activity such as manufacturing technology in a nation as developed as the U.S. is a formidable task, and must depend upon the marketplace, ultimately, but there are absolutely vital contributions for Government to make. This legislation addresses a particularly important segment of the Government role and we are pleased to endorse its basic provisions.

This ends my prepared testimony, Mr. Chairman. I will be pleased to respond to any questions you may have.

Senator GORTON. Our third panel will consist of Dr. Ansell, Dr. Berg, Dr. Holloman and Mr. Heaton.

We will hold off for a moment while a few photographs are taken. The next panel can get seated.

[Recess.]

Senator GORTON. I would like to get us back in order so that we can give this panel a sufficient amount of time between now and noon.

We will start this panel with Dr. Ansell's testimony. I am sorry all of the television cameras seem to have left, Doctor. You will have to think up something as spectacular as the last one to get them to return, I am afraid. But we, nevertheless, are vitally interested in what you have to tell us about these proposals.

STATEMENT OF GEORGE ANSELL, CHAIRMAN, MANUFACTURING STUDIES BOARD, NATIONAL RESEARCH COUNCIL

Mr. ANSELL. Thank you very much, Senator Gorton, and the rest of the committee.

Good morning. My name is George Ansell. I am the dean of engineering at the Rensselaer Polytechnic Institute in Troy, N.Y. I am also chairman of the Manufacturing Studies Board of the National Research Council of the National Academies of Engineering and Sciences.

It is in my capacity as chairman of the Manufacturing Studies Board that I want to be the primary focus of my remarks this morning.

Senator GORTON. Excuse me. If I may interrupt, Doctor, your written testimony will be included in the record in full. To the extent you can abbreviate it orally, we will have a chance to get through you orally and have an opportunity for questions.

Mr. ANSELL. That is my intention, sir.

As you know, the policy of the National Academies of Engineering and Sciences is that recommendations of the Manufacturing Studies Board that appear in congressional testimony must meet the same standard of objectivity and academic excellence as do their published academic reports. Thus, to support specific legislation, the Manufacturing Studies Board may offer to the Congress only those findings, opinions and recommendations it has offered to the public through the Academy publications.

Therefore, I offer on behalf of the Manufacturing Studies Board support from our publications for specific elements of S. 1286. I have spelled these out in detail in my written submission, and as you suggest, I would like to enter those into your minutes and not dwell on them, hopefully to increase the time for discussion.

In summary, the Board attests the importance of the issues and the severity of the problems addressed by the proposed act. We do so on the basis of our experiences individually and collectively in the fields of manufacturing, engineering and industrial development.

We believe that section 7 of the proposed S. 1286 treats today's manufacturing challenges from a very important perspective, that of industry-wide global competitiveness. The concern of the Manufacturing Studies Board with problems defined in this larger scale is equal to that for problems of technology development and diffusion.

One occasion on which the Board publicly addressed questions of global competitiveness was at a symposium entitled "Reindustrialization or New Industrialization." Speakers from five industries, the labor movement and the commercial news media joined your colleague from the House, the Honorable George E. Brown, Jr., in addressing questions of industrial competitiveness.

There is much to learn and many paths from which to choose in rebuilding the competitiveness of threatened U.S. industries, so continued efforts are needed. To reiterate this concern, I offer the following excerpt from the Manufacturing Board summary of the symposium's papers, and I quote:

"Many see the Nation's older industries as the focus of reindustrialization efforts. It is clear, though, that no industrial sector can feel secure. For example, the computer and semiconductor industries, among the brightest stars of today's economy, are facing serious competition in both markets and technologies. Other recently revitalized industries such as textiles are fighting hard to retain their domestic markets against aggressive international competition."

This concept of reindustrialization and the nature of the problems in manufacture are not old, mature industry problems; they are problems for all industry.

Other, more recent commentary on this need comes from the last annual meeting of the National Academy of Engineering, which took place in November 1982. The keynote speaker that day, Prof. James Brian Quinn, highlighted the diversity of threats to manufacturing competitiveness. I quote from his statement.

> Many companies have maintained their strength and foresight. But overall trends of U.S. actions versus those of other large OECD countries, notably Japan and Germany, show many points of weakness. Rates of savings and investment in the United States have been lower than in most competitor countries. Productivity growth rates correlate strongly with investment rates, and the U.S. productivity growth rate was fourth among the five major OECD countries between 1960 and 1980. Only the growth rate of the United Kingdom was lower.
>
> Virtually all U.S. manufacturing industries exhibited slowdowns in productivity growth during this period. Printing and publishing, primary metals, lumber and wood products, and aircraft and parts were the worst relative performers. Since there seem to be different root causes in each case, no single productivity policy is likely to yield desired results across all industry.

And that statement I think is the key one and will fit with my informal comments at the end of this presentation. There is not, in our view, a single solution or even a small family of solutions that address this very important and pervasive problem.

So with the causes of competitive pressures so numerous and often not uniform across industries, the need for continuing field research on competitiveness is evident. In sum, the Manufacturing Studies Board holds firmly the conviction that America's manufacturing, research and competitive challenges should stand prominently atop the country's policy agenda.

By aiding research and application in such fields as described in the bill before you today, the Congress could genuinely contribute to industrial efficiency and competitiveness. Emerging manufacturing technologies can bring higher quality American goods at competitive prices, as well as safer, more stimulating, and more rewarding jobs for industrial workers who are displaced as old technologies are replaced. We urge Congress to assist this transition.

Now I would like to depart from the summary of my written testimony and to extract some experiences, both from the Board and personally, which bear on the issues being discussed by this committee.

First, all of the improvements in manufacturing competitiveness depend upon people—talented, skilled and well-motivated people. Unfortunately, Senator, those people do not exist. Sufficient manpower is not in place now and will not be in place in the near future to develop and install the new manufacturing technologies. This situation is the result of the fact that our brightest and best young people in American universities and colleges, have not viewed manufacturing as an attractive career. Neither have manufacturing companies generally sought the best and the brightest for careers in this field.

The last 30 years in this country has been a period in which manufacturing has been in a hiatus, there has been no view of opportunity, advancement, or challenge. As a result, the infrastructure for manufacting education in American universities is not in place. The cost of putting that infrastructure in place is exceedingly high, and there is little being done today to address the issue. Only a few institutions have reasonable scale programs in manufacturing. In the over 200 engineering programs in the United States, there are less than a dozen active manufacturing programs.

In this regard, the United States is an anomaly among the Western industrialized nations. It is perhaps the only industrialized nation that does not seek or prepare the best of the graduates of engineering and science colleges to go into manufacturing careers. As a result, the United States has suffered and lost its ability to challenge the world for manufacturing leadership.

Second, the problem of improving manufacturing productivity is not just developing and exploiting the visible technologies—such as robotics and smart machines. These are but only a small part of what is a much more pervasive and very complex overall manufacturing system.

One example of the complex of elements required in this overall system is a development that was made by a Japanese engineer named Ono, an engineer employed by the Toyota Motor Co. What he did was look at the manufacturing system and realize that the seige mentality of protecting the factory production from the vagaries of suppliers by stockpiling large inventories was costly. What he did was invent the "just-in-time manufacturing" supply concept—the ability to have suppliers deliver the goods necessary just in time for the manufacturing process. This concept significantly reduced Toyota's manufacturing cost.

This technology is now being copied worldwide, a technology developed in a more vital and more vibrant environment for manufacturing research.

And finally in this country manufacturing has traditionally been a private sector initiative. Manufacturing in general has not been the purview either of the Government, and in most respects, or of the university. Indeed, the manufacturing industry in this country from the beginning of the century through World War II did very well as a private sector initiative. However, this type of initiative developed an adversarial relationship between the manufacturing industries and Government. As a result, it is my belief that Government does not now know how to help industry, and that industry is not sure really what it wants from the Government. Additionally, the universities' role in this process is far from clear.

An exception to this state of affairs has been the excellent work sponsored and supported by the Department of Defense and its contractors, but that effort, however successful, has not filtered well into either the small contractors and subcontractors or into the private sector.

In my opinion, we are dealing with a very complex issue. The bill before the committee today is a good and useful bill, but it only addresses a very small part of a very large problem, a problem that should be addressed in multiple ways.

Thank you very much for your invitation to testify.

[The statement follows:]

STATEMENT OF GEORGE S. ANSELL, PH. D., DEAN OF ENGINEERING, RENSSELAER POLYTECHNIC INSTITUTE, AND CHAIRMAN, MANUFACTURING STUDIES BOARD, NATIONAL RESEARCH COUNCIL, NATIONAL ACADEMY OF ENGINEERING

Good morning. My name is George Ansell. I am the Dean of Engineering at the Rensselaer Polytechnic Institute, Troy, New York. I have served for the last three years as a member of the Manufacturing Studies Board, National Research Council of the National Academies of Engineering and Sciences. For the past year I have been chairman of that organization. It is in my capacity as Chairman that I want to focus my remarks this morning.

In my effort to be helpful in your deliberations I have divided my comments into several sections. I would first like to share with you a little bit of the history and orientation of the Manufacturing Studies Board itself, and then go on to discuss in brief some of the current issues and activities of interest to the Board. By so doing I hope that I will convey to you the context for the issues you are addressing in the draft legislation before us (S. 1286). I would then like to draw from our work at the Academy some salient findings that bear directly on the legislative approach you are considering today. I then, of course, would be pleased to answer any questions you may wish to bring up.

The Manufacturing Studies Board was established in May 1980 to examine leading manufacturing issues for policy-makers in the federal government and elsewhere, including economic and social change, productivity, technology, innovation, related basic sciences, human and organizational behavior, governmental policies, and international competition. The board identifies and addresses manufacturing policy issues and opportunities and responds to requests by government agencies for advice in specific areas of manufacturing. An additional role of the board is to foster communications on manufacturing problems among relevant U.S. and foreign advisory groups, professional communities, government officials, and the public.

The board was developed as a result of a "think session" under the chairmanship of George M. Low, President, Rensselaer Polytechnic Institute, and former Administrator of the National Aeronautics and Space Administration, and Willis H. Ware, a recognized computer expert from the RAND Corporation. Their task was to outline the possible scope of a new manufacturing technology studies board after several attempts by the National Research Council to come to grips with the nation's perplexing decline in technological productivity and innovation. Concern about the slowdown of productivity and the troubles of manufacturing was then sometimes dismissed as simply a cyclical fluke or the worries of economists and businessmen about GNP and profits. The problems, however, proved to be more palpable and pervasive.

The need for a national focal point for these concerns was restated at a recent major technical session: [1]

A crucial aspect of the global economic position of the United States is its capability to maintain and even to expand its leadership in manufacturing. Manufacturing in the United States must undergo a period of rapid and important change. To maintain its leadership in manufacturing, the United States must increase the scientific base for manufacturing technologies, engage in worldwide competition, and serve world markets.

The ability of the United States to compete in world markets for manufactured products will increasingly depend on the ability and willingness of U.S. industrial firms to invest in and use the new generation of manufacturing technologies. Combined with new management philosophies these technologies offer a number of benefits: capabilities for dealing with the increased variety of products, shorter product life cycles, reduced inventory levels, increased levels of quality, faster response to design changes, and reduced costs. These are among the advantages that will be required for successful competition in the 1990s.

The technology is available to design and build factories with the above capabilities. The "factory of the future" can exist now, but it has yet to be realized on a broad scale.

There are several major barriers to greater adoption of these new technologies. Some of the technology aspects are not fully developed in the United States. Manufacturing engineers able to implement this increasingly science-based technology are scarce. And industry faces an increasing requirement for expensive capital.

Thus there is a need for the nation to focus attention on manufacturing; to examine changes in the manufacturing system and the driving forces that are causing change; to discuss state-of-the-art manufacturing technologies and practical problems of their implementation; and to investigate the effect of changes in U.S. manufacturing on the constituencies that have a major stake in the future and success of the U.S. manufacturing enterprise.

These constituencies include many industries in geographical areas of the United States that were once dependent on a manufacturing base for their economic livelihood but have subsequently lost their competitive ability. Many of the issues to be considered by the Manufacturing Studies Board can have significant impact on the long-term economic survival of these geographic areas. By addressing (a) the current state of U.S. manufacturing, (b) new manufacturing technologies, and (c) integration of the manufacturing system (changing design, production, and management relations, and changing demands on the education and training of engineers, technicians, managers, and skilled labor) the Manufacturing Studies Board can contribute significantly to the changes that will be necessary to make manufacturing based communities more viable economically.

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[1] "U.S. Leadership in Manufacturing," Technical Session, National Academy of Engineering Eighteenth Annual Meeting, November 4, 1982.

The task for the Manufacturing Studies Board then is to define the challenges facing U.S. manufacturing and to draw up an agenda for action.

In quarterly meetings designed to integrate the interests of the federal agencies the board: plans and reviews specific, separately funded activities performed by ad hoc committees at the request of federal government agencies; plans investigations initiated by the board to identify and define broad public policy issues in manufacturing for possible future study; carries out self-initiated studies reflecting the original intent and format of the board; and plans symposia on national topics of concern to the federal agencies and U.S. industry.

Historically, major projects of the kind planned by the Manufacturing Studies Board and its committees undertaken under the imprimatur of the National Research Council have had a significant impact on the direction and activities of the affected constituencies. It is the intention of the Manufacturing Studies Board that its written reports reflect an unbiased, well-thought-out consensus of experts regarding public policies and programs for government agencies and other interested parties.

The work of the Board is carried on primarily by a distinguished group of volunteers and a small professional staff.

Current interests and activities of the manufacturing studies board

The board has identified seven broad public policy issues in manufacturing and addresses aspects of these issues in its regular sessions.

At present the United States has no formal national manufacturing policy, although such a policy could be a means of improving manufacturing productivity. A manufacturing productivity improvement goal might be part of the policy.

Manufacturing technology is developed and applied in an environment that provides incentives and barriers to innovation and investment in manufacturing capability. Demand for new technology will cause changes in this environment and will, in turn, be shaped by such environmental considerations as regulations and standards.

Much public attention has been given recently to the competitive position of U.S. manufacturing in the world economy. The United States needs to solve the problems of export of technology and declining productivity growth and, at the same time, take advantage of opportunities to learn from the technology and practices of other countries.

Changes in consumer demand, technology, products, processes, and public policies will lead to changes in the strategy, organization, and management of manufacturing. Analysis of, and preparation for, these changes are needed before the factory of the future can be built.

Much of the existing manufacturing technology is not practically applied. Better use of current technology should follow from an understanding of the technology diffusion process, barriers to technology transfer, and strategies to stimulate transfer.

Technological developments are changing the requirements for manpower, education, and training. The displacement of workers by technological change can and should be minimized through policies that encourage appropriate education, training, and retraining.

As manufacturing technology continues to advance, information is needed on research and development needs and opportunities, including the manufacturing science base, "pacing" or limiting functions of technology, and robotics.

More specifically the Manufacturing Studies Board has identified 8 specific areas of concern which it is planning to explore in greater depth over the next 12 months. They include:

1. An Analysis of the Occupational Skilled Trades Shortage
2. Methodology for Introduction of New Manufacturing Technology into Small Companies

3. Transfer of Manufacturing Technology between the Defense and Industrial Sectors
4. Industry-Academia Cooperation in the Development of Manufacturing Processes, Manufacturing Technology, Manufacturing R&D, and Manufacturing Education
5. Impact on the Manufacturing Process of Labor-Management Relations
6. Review of Industrial Sectors in Competitive Difficulty to Identify Manufacturing Based Problems, Strategies, and Solutions
7. Materials in Manufacturing
8. Automation in the Electronics Industry

The Board has completed one major, separately funded study on behalf of the U.S. Air Force, which was a review of the Integrated Computer Aided Manufacturing (ICAM) Program. I will be drawing on the conclusions of this study later in this testimony.

In addition, the Board conducted a symposium on Reindustrialization and New Industrialization in January 1981, the minutes of which are available and may be of interest to this committee. I have listed this and other reports of the Manufacturing Studies Board that may be useful in your deliberations.

The Board is currently undertaking three independently funded studies:

The Committee on the U.S. Machine Tool Industry has completed Phase I of a two-phase effort. In Phase I, the committee assessed the machine tool industry's ability to respond to current and future mobilization needs of the Department of Defense (DOD). The objective was to identify recommendations that relate to the managerial, economic, and technical capabilities of the machine tool industry, and to plan a study of the machine tool industry's ability to respond to a DOD decision to implement any or all of such recommendations. The second phase is assessing the machine tool industry's ability to: (a) respond to current needs and potential national emergency requirements of DOD, and (b) be more competitive internationally. The objective is to identify policies or procedures in need of strengthening or modification.

The Committee on Industrial Policy for Developing Countries is analyzing the need for and will recommend a strategy for management training in seven developing countries to be specified by the Agency for International Development (AID). The Committee will (1) review existing reports and studies on training in each country; (2) send a team of two or three consultants (or committee members) to each of the seven countries to analyze further management education needs and to study the available existing resources and institutions. Each team shall include one experienced manager and one teacher of management; (3) review the teams' reports and organize for each an ad hoc panel of additional managers, teachers, and country experts to develop a final program for management training appropriate for adoption by the business and academic communities of the visited countries and which could be supported by the host country and AID's Bureau for Private Enterprise. The MSB will cooperate with the Board on Science and Technology for International Development of the Commission on International Relations.

Army Strategy for Using Artificial Intelligence and Robotics. A study to assist the R&D effort of the U.S. Department of Army by recommending military applications for robotics to replace or multiply the effectiveness of human combat and support resources and to identify technological trends that would significantly affect Army planning. The committee will (1) undertake a state-of-the-art review of artificial intelligence and robotics, (2) conduct a workshop to identify prime candidates for military (Army) uses of artificial intelligence and robotics, and (3) analyze and review the state-of-the-art review and the top two or three identified prime candidates for Army applications. The committee report will recommend a research and engineering strategy in the fields of artificial intelligence and robotics which will lead to the implementation of the applications identified in the workshops. The MSB will cooperate with the Board on Army Science and Technology and the Board on Telecommunications-Computer Applications in this study.

A planned, independently funded activity will be:

CAD/CAM Interface. The National Aeronautics and Space Administration has requested a study of the data flow from computer-aided design (CAD) to computer-aided manufacturing (CAM). This study of the CAD/CAM interface is intended to determine whether the interface suffers technical or managerial problems, and what the solutions to these problems may be.

CONCLUSIONS AND RECOMMENDATIONS

Recommendations of the Manfacturing Studies Board that appear in Congressional testimony must meet the standards of objectivity and academic excellence to which published Academy reports are subject. To produce reports that meet these standards, authoring committees and Boards share the tasks of research and writing among many members, who represent numerous relevant fields of endeavor and points of view. They then submit their work to the National Research Council's rigorous peer review system. Thus, to support specific legislation, the Manufacturing Studies Board may offer to the Congress only those findings, opinions, and recommendations it has offered to the public through Academy publications.

In this section of my testimony I offer, on behalf of the Manufacturing Studies Board, support from our publications for specific elements of S. 1286. Moreover, the Board attests with this written statement to the importance of the issues and the severity of the problems addressed by the proposed Act. We do so on the basis of our experiences, individually and collectively, in the fields of manufacturing, engineering, and industrial development and on the basis of our common commitment to the agenda we have chosen to pursue.

The Committee on Computer-Aided Manufacturing, whose work the Board oversaw and reviewed, published a number of reports that are pertinent to the proposed Act. In a 1981 report the committee states the following:

Because of the far-reaching potentials of CAD/CAM technology for increasing the efficiency and competitiveness of American industries, serious consideration should be given to developing governmental incentives and support for accelerating business commitments to the costly and somewhat risky efforts to harness these powerful potentials. Such contributions might involve support for relevant educational and research programs as well as favorable depreciation and other tax treatment of the investments involved.[2]

Elsewhere in the report the committee states the need for assistance in developing specific processes such as those listed in section 5.(a) of S. 1286. For example, the Act calls for research to improve the efficiency of "machine and process control strategies" [5.(a)(6)] and "practices and activities to implement improved manufacturing methods" [5.(a)(8)]. As evidence of this need, I offer the following excerpt from the committee's report.

. . . there seems to be no workable alternative to the progressive introduction of a number of organizational innovations if serious efforts are to be made to harness the potentials of broader CAM systems." [Companies must] "keep up with new developments on the hardware, software, and application frontiers; formulate plans to maximize the mutual reinforcement of sequential CAM applications; and provide educational programs to increase the interest and knowledge of other technical and managerial personnel in CAM principles and potentials.

Because line operations cannot be supervised on a continuing basis by the manufacturing technology staff, and because operations and progressive improvements are likely to be less than optimal if not driven by internal operating responsibilities, increasing CAM capabilities are likely to be needed among the engineers, maintenance personnel, operating labor, and supervisors within each major manufacturing division.[3]

The committee provides further support of Sec. 5.(a) in its discussion on "Evaluating CAM System Performance," a section that echoes the call in S. 1286 for greater involvement of academic and other independent institutions in assessing and promoting new manufacturing technology. The committee found (1) a lack of research and writing on the effects on productivity of manufacturing innovations, (2) a need to broaden the criteria of evaluation beyond the standard corporate concern with financial measures (which are often short-term), (3) a need to avoid other biases that can result when the evaluation of a system's effects is left to the corporate decision makers who introduced it, and (4) that emerging manufacturing capabilities of the kind listed in S. 1286, Sec. 5(a)(1–9) have an evolutionary nature, and that they will progress significantly with continued contributions and research. As the excerpts that follow suggest, expanded efforts at manufacturing research and assessment outside of manufacturing firms is an appropriate response to these needs.

(1) There is considerable literature on estimating the probable effects of technological innovations before decisions are made to adopt or reject them. But there is an astonishing paucity of research and writing on evaluating the actual effects of such innovations after they have been installed. Inquiries suggest that the reason for such neglect is the widespread assumption that the purposes, methodologies, applications, and interpretations of such undertakings are so obvious as to offer no inter-

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[2] The Committee on Computer-Aided Manufacturing, "Improving Managerial Evaluations of Computer-Aided Manufacturing," National Academy Press, 1981, 38.

[3] Ibid, pp. 30, 31.

esting problems. Our own field studies of such innovations, however, yield a sharply contrasting view.[4]

(2) Most efforts to evaluate CAD/CAM or other technological innovations tend to concentrate on financial criteria, especially on the level of outlays made and resulting operating costs relative to original expectations. But such findings may be inadequate and even misleading unless accompanied by a comprehensive appraisal of all other associated changes in the production operations affected. It is important to recognize that many of these critical determinants of performance are likely not to be adequately reflected by existing cost accounting measures.[5]

(3) One of the critical problems faced in appraising major innovations is the pressure for biased evaluations. Technical evaluations are usually left to the specialized engineers and the investment and cost evaluations to the respective specialists who are likely to have been involved in preparing the original estimates—partly because of the absence of qualified internal alternatives and partly to protect the confidentiality of findings. Moreover, those assigned to make such evaluations are often led to mute critical judgments lest these inhibit future cooperative relationships with the officials responsible for such projects.[6]

(4) In the case of CAD/CAM applications, additional projects and extensions tend to represent a blending of unique elements with considerable common elements. Hence, substantial benefits may result from using ex post findings of past installations to uncover the loci and primary causes of significant deviations from expectations as a basis for identifying those likely to be influential in later applications as well.[7]

Section 7 of the proposed S. 1286 treats today's manufacturing challenges from another important perspective, that of industry-wide global competitiveness. The concern of the Manufacturing Studies Board with problems defined on this larger scale is equal to that for problems of technology development and diffusion. One occasion on which the Board publicly addressed questions of global competitiveness was its symposium entitled, "Reindustrialization or New Industrialization," which took place January 13, 1981. Speakers from five industries, the labor movement, and the commercial news media joined your colleague from the House of Representatives, the Hon. George E. Brown, Jr., of California, in addressing questions of industrial competitiveness. There is still much to learn and many paths from which to choose in rebuilding the competitiveness of threatened U.S. industries, so continued efforts are needed. To reiterate this concern, I offer the following excerpt from the Manufacturing Studies Board's summary of the symposium papers.

The word "reindustrialization" was coined to suggest responses to a range of economic problems that, for many, are symptoms of industrial and economic deterioration. The sudden appearance of an international balance of payments deficit in 1974 and its growth since provided a key signal that the nation's economic health was impaired. In the past few years, plant closings, double-digit inflation, declining productivity growth, and the purchase of many American assets by foreign interests have brought the economic condition of the nation increasingly to the attention of the government, news organizations, industry, labor, and the general public.

Many see the nation's older industries as the focus of reindustrialization efforts. It is clear, though, that no industrial sector can feel secure. For example, the computer and semiconductor industries, among the brightest stars of today's economy, are facing serious competition in both markets and technologies. Other recently revitalized industries such as textiles are fighting hard to retain their domestic markets against aggressive international competition.[8]

Other, more recent commentary on this need comes from the last annual meeting of the National Academy of Engineering, which took place on November 4, 1982. The keynote speaker that day, Professor James Brian Quinn, highlighted the diversity of threats to manufacturing competitiveness.

Many companies have maintained their strength and foresight. But overall trends of U.S. actions versus those of other large OECD countries (notably Japan and Germany) show many points of weakness. Rates of savings and investment in the United States have been lower than in most competitor countries. Productivity growth rates correlate strongly with investment rates, and the U.S. productivity growth rate was fourth among the five major OECD countries between 1960 and 1980. Only the growth rate of the United Kingdom was lower.

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[4] Ibid, p. 32.

[5] Ibid, p. 33.

[6] Ibid, p. 34.

[7] Ibid, p. 35.

[8] Manufacturing Studies Board, "Reindustrialization or New Industrialization: Minutes of a Symposium," National Academy Press, 1981, 1.

From 1970 to 1980 productivity in manufacturing industries grew almost four times faster in Japan (up 102 percent) and twice as fast in France (up 61 percent) and West Germany (up 60 percent) as in the United States (up 28 percent) in ten years. The United States still has the highest productivity levels among these countries as measured by GNP per person employed. Nevertheless, the U.S. lead in productivity has decreased over the past decade.

Virtually all U.S. manufacturing industries exhibited slowdowns in productivity growth during this period. Printing and publishing, primary metals, lumber and wood products, and aircraft and parts were the worst relative performers. Since there seem to be different root causes in each case, no single productivity policy is likely to yield desired results across all industry.[9]

With the causes of competitive pressure so numerous, and often not uniform across industries, the need for continuing field research on competitiveness is evident.

In sum, the Manufacturing Studies Board holds firmly the conviction that America's manufacturing research and competitiveness challenges should stand prominently atop the country's policy agenda. By aiding research and application in such fields as are described in S. 1286, the Congress could genuinely contribute to industrial efficiency and competitiveness. Emerging manufacturing technologies can bring higher quality American goods at competitive prices as well as safer, more stimulating, and more rewarding jobs for industrial workers who are displaced as old technologies are replaced. We urge the Congress to assist this transition.

Thank you for the opportunity to comment.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR GORTON AND THE ANSWERS THERETO

Question. The university research community has been a major source of scientific and technological innovations in many fields. But universities appear to have given manufacturing engineering a low priority and there are only a small number of programs in manufacturing technology in U.S. universities.

Would you compare the priority given by our foreign industrial competitors to manufacturing research and education?

Answer. This situation is radically different in the industrialized countries in Western Europe and Japan. In these countries, where productivity rates continue to grow dramatically, there has been a long-standing cooperative effort between major manufacturing industries and the technical universities. On a visit to Europe I was particularly struck by the situation in West Germany. The universities in Aachen, Stuttgart and Berlin have large, prestigious graduate programs focused on manufacturing. In each of these manufacturing programs, more than 100 of their best engineering students are working full time on manufacturing projects. These projects are placed in the universities by the manufacturing industries, such as Siemens and Volkswagen.

The German manufacturing programs attract the best engineering students—drawn by the challenge of the work—the opportunity to solve a variety of manufacturing problems that are at the leading edge of technology and that are of practical importance. The students are paid industrial salaries and are expected to perform accordingly.

These bright, ambitious students are motivated by clear signals from industry that manufacturing is important to them. Indeed, manufacturing is the path to corporate leadership. The graduates are aggressively hired into responsible manufacturing positions. The alumni of these programs have moved quickly into the top management of Germany's manufacturing industries.

These university centers are part of a national resource, which in cooperation with business and government, fuels Germany's drive toward industrial growth.

The educational programs are practically oriented—paced by the manufacturing projects placed by industry. In addition to providing solutions of manufacturing problems, the continuing contact between the students and the industrial sponsors provides an effective means of channeling highly skilled and motivated engineering talent to industry on a continuing basis.

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[9] National Academy of Engineering, "U.S. Leadership in Manufacturing: A Symposium at the Eighteenth Annual Meeting," 25, 27.

The contrast between the university's role in manufacturing in these countries, and that in the United States is both striking and unfortunate. There are only a few universities in this country which focus on problems relevant to manufacturing. It is only within the past few years that we are beginning to see the development of joint industry-university research efforts in manufacturing.

Question. How does the vitality of manufacturing research and education compare with other engineering disciplines (for example, electrical, aeronautical, and chemical)?

Answer. The vitality of manfacturing research and education simply does not compare with the other engineering disciplines. Engineering research education has stimulated graduate research in the universities. Traditionally, most graduate research efforts have been funded by government in the advanced technologies and applications required by government's perceived needs. There has been little equivalent incentive for the development of advanced technology and its transfer to the problems of industrial production. As a result, there has been little university research and education in the area of manufacturing systems on a basis which is equivalent to government-sponsored research in most of the other engineering disciplines.

However, although the interests of government agencies have had little bearing on manufacturing problems, the research they have sponsored has produced strengths in underlying or generic technologies which could be exploited for applications in manufacturing. The strengths in these underling technologies provide a potent resource in the university that can be directed and effectively applied to manufacturing problems, These technologies, such as operations research, computer graphics, automatic control, mini-and micro-computers, tribology, robotics, artificial intelligence, CAD and CAM, materials, and so on, are resources waiting to be tapped. As a result, the capability which now exists in U.S. universities, is pre-eminent in the Western World. Whether or not these resources are applied to help solve our productivity problems depends on developing a major support base for university reearch and education in this field.

Senator **Gorton**. Thank you, Dr. Ansell.

The second witness is Dr. Daniel Berg of Carnegie-Mellon University and the Association of American Universities.

Dr. Berg.

STATEMENT OF DANIEL BERG ON BEHALF OF THE ASSOCIATION OF AMERICAN UNIVERSITIES

Mr. **Berg**. Thank you very much, Senator Gorton and members of the subcommittee.

There is a great deal, of course, that one could say with regard to the bill. In view of the time, I will try to confine myself to just a few issues.

Clearly, some of the key issues confronting our domestic manufacturers are our competitiveness and capabilities with regard to processes and so on. Others have likened the situation to the United States playing two Super Bowls simultaneously: Super Bowl I with respect to our military competitors—and I am glad that Dr. Ansell just mentioned DOD's role in this—and Super Bowl II with regard to our economic competitors.

And, clearly, it is in our national interest to have our domestic manufacturing capability second to none in both productivity and competitive capabilities. I just want to focus my comments on a few parts of the bill, S. 1286.

I think there is a good deal of deserved emphasis in the bill on the conducting of research which will produce more efficient technologies and on the conducting of research utilization activities to encourage widespread adoption of research outcomes. I think this latter is a very critical issue and one that is overlooked, especially when universities and their roles are discussed.

It is not only a question of advancing the scientific and technical capabilities of our manufacturing industry, but also an issue of having these technologies incorporated into our daily economic lives. And this technology transfer is as important as creating new developments.

I can give you a few examples of this from my own experience in our research programs, but I will focus my comments primarily on the robotics area.

At Carnegie-Mellon University we deliberately keep our robotic funding to 70 percent from industry. It would be quite easy to get much higher funding from Government agencies, particularly DOD, but we deliberately maintain that ratio.

We do this because we want the technology we are developing to be incorporated by the prime user, which of course means industry. In addition, the work we are doing requires a special laboratory—in this case, the factory floor—and for us this is only accessible through industry.

Examples of this need of interrelationship abound, but one clear-cut example today is in the growing science of artificial intelligence and its subdisciplines such as knowledge engineering and expert systems. And to conduct leading-edge research in this area requires its adoption and utilization by industry. It is not enough to do research in this area without having simultaneous access to industrial problems and methods.

One of the earlier witnesses was asked about science in this, and one of the historical examples that a colleague of mine uses, and he claims he would predict the same thing will happen in the manufacturing area, specifically the robotic-manufacturing area, is the example of thermodynamics. That was a development that very much came out of the activities in England where they had to pump water out of coal mines in order to get the coal to fuel the industrial revolution, and the intense work to improve efficiencies of the steam engine led to a science known as thermodynamics. There is a feeling that the same thing will happen here by working on real, practical problems.

Another issue I would like to endorse, although I do not see it spelled out as strongly in the bill as I would like to see, is the concern for the societal impact of these new technologies. I do not think at this point anyone really knows enough to predict with any certainty what these impacts will be. You hear all kinds of predictions all over the lot, but I think it is critical there be research done, not only to develop the technology, but also to try to understand the societal impact a little better.

Although I am really in favor of most of the bill with regard to the need for and encouragement of R&D for new manufacturing technologies, and especially the mechanism for collaborative effort between industry and the universities. I must say I do react negatively to the section which talks about a geographic dispersion of the centers envisaged in this act.

I think the issue is really to get the technology developed at the places and in the areas of the Nation where there is the highest probability that outstanding and innovative technology will be developed and expeditiously and effectively transferred.

To consider dispersing it geographically is, I think, beside the point and may weaken the critical mass of resources needed for effectiveness at any one site.

In summary, I agree with the basic objectives and approach of the bill. I think the concern for retraining of displaced workers in advanced manufacturing methods is appropriate and necessary. I think the setting up of the advisory committee to review the policies and selection criteria for grants and to commission competitive studies is very much in order.

My sole reservation is my objection to the dispersion of centers based on geography.

Thank you.

Senator GORTON. Thank you very much. We will now go on to Dr. Hollomon and Mr. Heaton, both from Massachusetts Institute of Technology. Dr. Hollomon.

STATEMENT OF J. HERBERT HOLLOMON, JAPAN STEEL INDUSTRY PROFESSOR OF TECHNOLOGY, CENTER FOR POLICY ALTERNATIVES, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, ACCOMPANIED BY GEORGE HEATON, PRINCIPAL RESEARCH ASSOCIATE, CENTER FOR POLICY ALTERNATIVES

Mr. HOLLOMON. Mr. Chairman, after following that marvelous marketing presentation, I simply want to say that I only have one hand and that my means of getting here, I do not think you saw, is a very attractive aide who comes with me, and I do not want any damn robot pushing me in this room.

Senator RIEGLE. And you are better looking.

Mr. HOLLOMON. Furthermore, she has senses that that robot does not have, I am sure. The other comment is I think I need some artificial intelligence. I am a little confused by everything. I always have been. So, that is not new.

Mr. Heaton and I have prepared a testimony and have submitted it. What I would like to do here now briefly is to discuss some of the key issues which I think are involved in all three pieces of legislation before your committee.

Senator GORTON. We would be happy to have you do that and all of your written testimony will be included and printed into the record.

Mr. HOLLOMON. Thank you, sir.

First, I would like to make a general comment about all three pieces of legislation. They all make a basic assumption. The assumption is that technology is the problem and technology is the solution.

I am not sure that that is correct, in terms of our present productivity and competitiveness, particularly vis-a-vis Japan. I suspect, and I think the evidence is growing to support my suspicion, that the major problem of our competitiveness, the quality of our products and productivity, is management and not technology.

I personally have visited and many of my friends have visited Japanese factories, and more and more the conclusion is that the techniques they use, that is the hard techniques, the machines, the robotics and what have you, are not leading the United States. Something else is behind in this country. That is the relationship between the supervisor, the manager and the worker and the environment in which they work.

I would argue that the difference in productivity between Japan and the United States is basically and fundamentally a managerial problem already mentioned here obliquely in an earlier testimony in which the name of Edward Deming was mentioned.

Let me say a few words about Mr. Deming. Mr. Deming is now an older man. I cannot say an old man, because he is only 20 years older than I am. But he is an older man and he was brought in by General MacArthur after World War II to help the Japanese industry improve the quality and productivity of Japanese products. What he said was relatively simple: the manager of the plant must understand what the plant does—what is its technical system and how does it work.

Second, he must trust the workers on the production line, and they, in turn, must control the quality and the productivity. It is remarkable that Japan is one of the few places where I have ever seen a worker on a production line pull a switch and shut it down because the product does not meet his quality standards. And that is the way many Japanese factories operate.

Furthermore, the general relationship between supervisor, management, and worker in Japan, and in some plants in the United States, is one of trust. I believe that basically and fundamentally what we must learn to do is to trust our fellow human beings and not have this adversary relationship between them and us, whoever the hell them and us are.

So, I would like to, as strongly as I can, say while I support, and state so in my written testimony, many of the features of your bill, sir, we do think that there are some dangers in overemphasizing the technological solutions to these problems.

That is strange coming from me. I grew up in technology. I am a graduate of MIT. I worked in the research function of GE. I was in charge of the Central Engineering Organization of the General Electric Co., and here I am up here saying that ain't the key problem. You know, that is hard for me after all of that indoctrination. That is difficult. But it is the truth, I believe.

I believe the key problem in the United States has to do with education, educating new people, as these gentlemen have both said, to go into manufacturing and manufacturing management, and educating experienced people to adjust to the changing times, as all of you have said.

I believe that the key aspect of any legislation that you approve has to do with education, not necessarily only in the university, but education on the job, education for technicians, education for high school students.

For example, Mr. Deming said, which I think is very interesting, that every worker and every manager in the factory had to understand statistics, that you could not control quality unless you understood statistics. Deming's principle is a fundamental of the Japanese high school education system. The high school student must understand statistics.

Now let me say one other word about Mr. Deming before I quit. Every year the company that is the most productive and has the highest quality product in Japan gets the Deming prize. One of the earlier witnesses said it was reprehensible to have Sony devices taking movies, but I believe that to have an American be the epitomy of Japanese quality and productivity while we ignore him is even more reprehensible.

The second major issue in all three bills has to do with selecting technologies in which the country should make investments—technologies which will be, in the future, economically valuable. I think such selections are dangerous. What is wrong with it? On the one hand it is so appealing, because if we just had sense enough to select the technologies that were important and invest barrels of money in them, we would just let the flowers grow where they may.

First off, I think it is very hard to do. Second, I think it is dangerous, because people will begin to believe in the chosen technologies and nothing else. I think all of you here remember, as I do, the time when every country in the world and every government wanted to support aeronautics and nuclear powerplants. We got on a train going down a track and we stuck to that track. We made enormous investments in these things.

The third comment I would make about targeting is that I believe it leads to more centralization in the United States than has been our historical, political heritage and I think that is dangerous.

On the other hand I would say that the targeting in S. 1286 is probably sounder and better thought out than in the other two pieces of legislation.

Let me say one other thing and that is if you are in a contest, like a boxing match, and someone is beating the hell out of you, what you do not do is fight him the same way he is fighting you. The thing you do is to fight him another way.

Everybody in the world is now targeting technologies. I can even tell you what the targets are. You do not need a study group or a vice president; all you have to do is look around the world and see what they are. The targets are VLSI, robotics, biotechnology, and so forth. Those are the targets. And we can get think tanks thinking for a long time and they will come up with the same answer, I assure you. I am not trying to be arrogant. There are hundreds of people who have studied this matter of targeting in almost every country in the world. And they come up with the same answers.

Now, what do we do when we are all in the same business? What kind of competition is that? All of us have the capacity to do the same thing and that strikes me as not a very effective way to compete. It strikes me that we ought to do something different.

What should we do that is different? I believe that one of the things we should do that is different, and this has been discussed by many people here today, is to insure that we are right now plowing the field as well as we know how. In other words, we should enact legislation along the lines I understand Senator Riegle is considering. This is an industrial extension-type program, which teaches people what we already know how to do and does that by not only teaching in the normal sense, like we are doing today, but also by demonstration. Moreover, it not only teaches technical things, like robots, but it also teaches management skills.

Seriously, I believe that legislation of this kind is one of the most important things we could do about competitiveness in productivity in the United States. We already have a model; we know it will work. The model of the agricultural extension program, beginning in the middle of the 19th century, is the model of the world for developing an agricultural economy.

I ask the question, as I did in 1955, why cannot we do that with respect to industry? Why cannot we have the least productive company in an industry doing things as well as the most productive company. There are studies in the Commerce Department that indicate the difference between the average productivity of companies in a industry compared to the most highly productive companies. These numbers differ by about factor of two. Can you imagine what a factor of five in the productivity of a number of industries will do to the productivity of the United States?

Progress is right there to be had. What we have to do is organize a mechanism that is funded and supported by the Federal Government and carried out largely by the States, decentralized. I do not believe you can operate either an agricultural or an industrial extension program from Washington. I think it has to be done out there in the field. That is something we can do that is different from what other countries are doing.

The second thing we can do that is different is to assume that the best way to select technology is to let firms select it rather than the Government. In this regard I believe that the best policy is to do everything necessary to support entrepreneurship—the establishment of new companies in new fields—everything we can to aid in the entrepreneurial function and remove the barriers to small companies' startup and growth.

The kinds of things that I mean are the arrangement of conditions for which, for instance, early startup money is available to small firms, either in the form of grants or loans.

In Japan, there is an interesting policy. In every prefecture there is a government laboratory supported by the state, that is the prefecture, and the Federal Government, to which a small firm can go to get technical work done at very minimum cost or no cost at all on a new product it wishes to develop.

In Korea, there are now zero interest noncollateralized long-term commercial loans to small companies in the early stages of their development. This is money which I refer to as mother-in-law money. If I want to start a small company, I have got to borrow money from everyone, my mother-in-law, my wife, my friend George. That is how they get started.

I think there is a problem of availability, not of venture capital, but rather the funding before venture capital—what I would refer to as high risk startup money. There are all sorts of governmental or quasigovernmental institutions around the world by which such money is made available; and they exist in Japan, Korea, Israel, West Germany, and France.

Once a company gets started, then the problem is venture capital. I believe increasingly in the United States, as the Congress in its wisdom has changed the capital gains laws, venture capital is increasingly available. I believe that any small company with a good staff and a good idea can get venture capital to an almost unlimited extent.

I think that is about it. I have two other very small items I would like to bring up. One has to do with this question of labor displacement. I do not think you can understand displacement of workers by thinking about it alone. I think you have to have a laboratory. I think you have got to find out what is happening on the factory floor when a new technology is introduced. How are workers changed and displaced? Now, one of the key factors here is that the management has to change. The way the management is thinking has to change as well as the workers.

So, with regard to social impact, which I believe is so important, I believe the way to study social impact is to be able to include in the research program, which is in this bill, research activities jointly between industry and universities which use the industry as the laboratory and understand that that is different from other kinds of research and development.

We have a program at MIT which George and I have been involved in for 5 or 10 years which, by the way, is very interesting. It was funded initially by the Caterpillar Tractor Co. We were trying to bring together a group of companies to support an activity using those companies' factories as laboratories.

I believe, Senator Riegle, to answer one of your questions, I believe that is the way to find out what the impact is likely to be. Let us find out what it is. What is going on out there when Caterpillar spends $150 million on automation? What is happening to the entry-skilled worker? What is happening to the firstline supervisor? Those are the kinds of things I think can be done with respect to impact.

I agree with someone who said I do not think we know what the impact is liable to be. I think it can be learned, but I do not think we know.

Those are my comments, Mr. Chairman.

[The statement follows:]

STATEMENT OF J. HERBERT HOLLOMAN, JAPAN STEEL INDUSTRY PROFESSOR OF TECHNOLOGY AND POLICY, MASSACHUSETTS INSTITUTE OF TECHNOLOGY AND GEORGE R. HEATON, JR., PRINCIPAL RESEARCH ASSOCIATE, CENTER FOR POLICY ALTERNATIVES, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

We greatly appreciate the opportunity to present our views to this Committee on the several bills now before it concerning manufacturing and industrial competitiveness. The problems related to manufacturing productivity, managerial techniques for improving product quality, the diffusion of knowledge about these issues, and the process of developing new technologies are of critical importance to the United States—now more than ever before. The reverses suffered by some of our industries in international trade are painfully obvious. Unemployment continues to be unacceptably high. And we still, in spite of what appears to be an obsession nowadays with our economic problems, have many social ills to attack. These—for example, the relationships between workers and managers or the quality of our educational system—are in fact intimately connected to our country's economic performance and therefore deserve attention for this reason as well as because of their inherent importance.

The bills on which we will comment today, S. 1286, S. 632, and S. 428, all attempt to address some aspects of these issues. This is all to the good. These issues must be addressed—first, by creating an awareness that pressing problems do exist; second, with research and study to understand the nature of the problems; and third, by actions to begin to solve them. In addition, we are supportive of the motivation behind these proposed pieces of legislation—and some of their substantive provisions—because we believe that it is the appropriate function of the government to address such issues of this nature. While the government obviously cannot mandate economic rejuvenation, its actions can nevertheless catalyze the private sector and solve problems that the private sector either ignores or refuses to address. Our government has traditionally proceeded on this assumption, and the governments of other highly industrialized countries have certainly exhibited a pattern of concern for their nations' industrial competitiveness. Particularly where the issues of concern are of great magnitude and particularly where no actor in the private sector has the resources or interest to address them adequately, the government is compelled to step in. In fact, the development and diffusion of improved manufacturing techniques of general use to industry provides an excellent example of both of these preconditions for public action. Thus, we are generally in favor of initiatives such as those contained in these three bills because of the importance of the issues, the need for public debate about them, and the necessity for a governmental role. Having said this, however, we should emphasize that we do not agree with a number of the specific provisions the bills propose, and, to some extent, our views about the nature of the problems facing the country (and consequently, about the solutions as well), differ from the assumptions that all three of the bills implicitly make. The remainder of this statement outlines our view of the problem, the differences in approach it implies from what is contained in the three bills, specific comments on some of the provisions, and some concluding remarks of a more general nature.

The U.S. does indeed have a problem with respect to manufacturing and industrial competitiveness. In our view, the problem is not exclusively, or even principally, a problem of "technologies"—if one takes this to mean a need to develop and implement new machines or other sorts of capital equipment for use in factories. On the contrary, most of the research of which we are aware comparing manufacturing in the U.S. and abroad indicates that levels of technological sophistication and capital investment are equal or higher in the U.S. than elsewhere. For example, this is a conclusion William Abernathy from the Harvard Business School came to quite early about the Japanese and U.S. automobile industries, and it has been supported by a subsequent review of automobiles by the National Academy of Engineering. We feel that the problem the U.S. has is perhaps best described as one of "technique." By this we mean the appropriate use and integration of technologies into a social context. Thus, our manufacturing industries must, to solve their problems, learn methods of quality control, worker involvement in decision-making, mechanisms for keeping abreast of technical developments throughout the world, ways of optimizing legitimate social demands, like environmental amelioration, with productivity improvements, and so on. Of course, we do not mean to imply that our problems are all social, organizational, and attitudinal rather than technical. Indeed, developing new technology is imperative for industrial competitiveness, and there is a great deal of technical training to be done—the manufacturing curricula of engineering schools throughout the country are woefully inadequate or nonexistent. We do want to emphasize, however, that the development of new technology, important as it is, will not solve our problems in manufacturing. In fact, if there is not more emphasis on manufacturing techniques and the appropriate integration of technology into its social context, the problems may get worse.

The three bills before this committee share a common, but somewhat inaccurate, view of the nature of the country's problems with respect to manufacturing and industrial competitiveness. It seems a fair characterization to say that each of the three assumes the fundamental problem to be the development of new technologies. This orientation comes through most strongly in S. 428, which would identify and propose development plans for "economically strategic technologies." S. 632 appears to have a slightly broader view of the problem, since its task force would examine government programs for technology development, but its essential focus, too, is on identifying and developing "frontier technologies." Although S. 1286 addresses the general issue of manufacturing, its basic assumption, again, is that the promotion of certain enumerated technologies—computer-assisted design, robotics, automated sensing, etc.—will almost automatically improve the national competitiveness in manufacturing fields. Among the three, only S. 1286 gives nodding recognition to the problems of implementation and utilization of these technologies, and none of the bills addresses the underlying concerns of worker training, managerial practices and attitudes, educational levels, knowledge dissemination, and social context which, we believe, are such critical aspects of the overall problem. Because each of the bills takes a too-narrow, too-technological view of the problem, each tends to go too far in the direction of technology promotion and not far enough in the direction of improving the techniques related to manufacturing and the climate or preconditions for technological development. The following paragraphs offer some more specific comments on each of the bills.

S. 1286 is legislation we support, even in its present form, although we believe it could benefit from the addition of provisions focused on technical training, education, demonstrations, and information dissemination. It is likely to be of assistance in overcoming existing problems and in promoting the long-term competitiveness of U.S. industries. The U.S. does not now have a healthy, vigorous set of research activities in manufacturing sciences or enough engineers, technicians, and managers trained in modern manufacturing methods. S. 1286 would help remedy these deficiencies. Its two-tiered research program (Section 5 on manufacturing methods, and Section 6 on utilization) is sensible, as is the ability of the Secretary of Commerce to contract and cooperate with any kind of organization in the promotion of these programs. The program proposed should be expanded, however. First, its focus should be extended to include managerial techniques. Second, it needs a training component. No mention is made of the need to develop curricula related to manufacturing. We believe that grants or contracts under the legislation proposed should be available for training or course development by universities, other educational institutions, or in-house efforts among manufacturing companies. Third, the bill lacks a mechanism for promoting the dissemination of the knowledge it will generate or for disseminating existing knowledge about manufacturing techniques. This issue might be addressed in any number of ways. In our view, the best method of dissemination would be via state technical extension services, an issue which, we understand, Senator Riegle is addressing in legislation to amend the State Technical Services Act of 1965. Lastly, the bill should explicitly recognize the need to consider the social aspects of manufacturing, e.g., worker participation, worker and consumer health and safety, in the design of improved production processes. Two other aspects of S. 1286 are particularly worthy of compliment. The competitiveness study mandated by Section 7 is both a sensible idea and sensibly constructed. The assignment of responsibility for both the study and other programs to the Commerce Department is desirable in light of existing institutional capabilities because it combines the missions of study and action and because it assigns responsibility to an Executive Branch official who can be held accountable.

S. 632 and S. 428 are bills that we can not endorse in their present form, and could not do so unless they were substantially altered. Both are examples of what is termed "targeting"—an exercise in which the government designates particular industries or technologies as economically strategic and then directly supports their development. Not only does the general concept of targeting suffer from severe shortcomings as a policy instrument, particularly from an American perspective, but the application of the concept in these two bills also seems flawed.

The goal of targeting—industrial competitiveness in important sectors—is one that few quarrel with. Our reservations, thus, focus on the mechanism—whether it can work and what its adverse consequences might be, whether it works or not. One problem with targeting is the inability of government officials to pick the right targets. If the result of choosing wrong were simply the ineffective use of government program monies, it would not be great cause for concern. However, since targeting is as much a catalyst to private sector investment as it is a government expenditure, wrong choices become extremely costly. In addition, a targeting system seems particularly prone to faddishness: virtually all developed countries today are promoting biotechnology, robotics, VLSI, and a few others. Certainly not all of them can hope to be successful, and almost certainly there will at some point be an overcapacity in these sectors. A second basic problem is that targeting may not be the most effective way of promoting the development of a new technological area. If, as it often turns out, the second stage of targeting is to undertake large-scale funding of R&D, we are skeptical about the end results. What may be more effective instead is a variety of measures—for example, government procurement, tax incentives, information dissemination, etc.—that encourage demand for the technology. A third basic argument against targeting is that it is inconsistent, on a basic level, with the American system of government and with the structure of our economy. In contrast to many other countries, our government has been pluralistic and our industrial structure decentralized. This has been, in our view, a great strength of American society, and we see dangers in substituting for it the centralized designation of approved sectors that targeting implies. Much of the enthusiasm about targeting in the U.S. arises from the fact that other countries have employed it with apparent success. Even here, a note of caution is in order. Japan, for example, though perhaps the leading exponent of targeting, now appears to be moving away from this strategy. There is a strong body of sentiment among both business people and government officials in Japan that what the country needs for the future is less centralized targeting and more pluralistic creativity.

Having expressed these reservations about the concept of targeting as it seems to be exemplified in S. 632 and S. 428, we should say that we can still envision a role for government that does incorporate some of the features of these bills. There are indeed many areas of technical inquiry the government should support. Mostly, these are areas that represent important scientific questions and thus should be supported for the sake of gaining this important knowledge, not necessarily because of their presumed economic value. The Max Planck Institutes in Germany are a model of this type of activity which we might well emulate. It is also appropriate, in some circumstances, for the government to move beyond generic support for scientific and technological development to fund research and engage in other supportive activities with respect to specific technologies or industries. And there should be no objection, in principle, to supporting particular activities in individual firms. The circumstances that would make such a government undertaking appropriate include first, that the area to be supported is important scientifically or economically; second, that the research proposed is of high quality and likely to be successful; and third, that the work would probably not be undertaken without public support. Naturally, planning and analysis must precede such a programmatic activity, and some people may see our proposals as being close in concept to the targeting programs we have been criticizing. Although there is some overlap, an essential difference separates them. In our view, it is neither likely that the government can nor desirable that it should systematically target technological investment a priori; rather, government support should be more ad hoc, responsive to private sector proposals, and based on gaps in private sector ability or resources.

In addition to these fundamental deficiencies in the programs proposed in S. 632 and S. 428, both pieces of legislation are somewhat flawed in terms of the studies they mandate and the institutional actors involved. In particular, the effort outlined in S. 632 is too ambitious to be undertaken in one year by a task force. Its request for a study that identifies and evaluates all government programs of technology support is probably not do-able at all. Moreover, the study design ignores the negative influences existing programs may have on technology development or the positive but unintended or indirect effects of other governmental activities. The study design proposed by Section 7 of S. 1286 is more appropriate. Not only is it more modest and flexible in scope, but it also would be carried out within the Executive Branch rather than by a task force or Academy panel. Thus, its implementers would be more accountable and better able to translate their research findings into programmatic initiatives. The best institutional home for such a study, however, would be a National Technology Foundation, if one were to be established in the future.

We do not mean to suggest from the foregoing remarks that targeting cannot work. On the contrary, it appears to have worked quite well in some countries in the past. Perhaps the best recent example of targeting is the Swedish case. Recently, the Swedish Academy of Sciences began a study to identify and propose development plans for strategic sectors. This study was funded by STU (The Swedish Board for Technical Development, a rough equivalent to the proposed U.S. National Technology Foundation) and it was known in advance that STU would implement the study's recommendations. The report that ensued produced the expected list of strategic sectors, but it also produced recommendations for improving the climate for innovation generally and for encouraging the establishment of new, technology-based enterprises.

These last recommendations of the Swedish study furnish a good illustration of the last point we would like to make: that the promotion of innovation and entrepreneurship in general is a better way to gain international competitiveness than a series of targeting programs. In a sense, we propose that the country target and encourage entrepreneurship rather than any specific technology. This must be done by many means, including tax policy, government procurement, policies pertaining to venture capital, protection of intellectual property rights, and antitrust actions, among others. Targeting entrepreneurship is undoubtedly a more difficult enterprise than targeting technologies, and its success will certainly be harder to evaluate. Nevertheless, it is likely to be the country's best long-term strategy. We reach this conclusion on the basis of an expanding body of research showing the importance of new companies to innovation, the record of other countries' experience, and the belief that this decentralized approach is most consistent with the unique strengths and structure of U.S. society.

We thank the Committee for the opportunity to submit this testimony.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR GORTON AND THE ANSWERS THERETO

Question. The university research community has been a major source of scientific and technological innovations in many fields. But universities appear to have given manufacturing engineering a low priority and there are only a small number of programs in manufacturing technology in U.S. universities.

Would you compare the priority given by our foreign industrial competitors to manufacturing research and education?

Answer. The first set of questions concerns the attention U.S. universities have given to programs in manufacturing technology. We believe that other countries, most notably Japan and West Germany have given higher priority to manufacturing research and education than the U.S. has. In general, however, this is not because their universities have been better at providing training in these fields. On the contrary, U.S. universities probably offer better programs in manufacturing technology than what exists in either Germany or Japan. These two countries have more than made up for the relative lack of such curricula in their universities by having excellent training programs in manufacturing firms. This is particularly true for Japan, where in-house training is widespread. In Germany a significant amount of training in fields related to manufacturing has occurred in the institutes of the Frauenhofer Gesellschaft, whose programs in these areas have been ahead of those in the U.S., at least until recently.

In the U.S., the vitality of manufacturing research and education has been poor compared with other engineering disciplines. We believe that this is more the fault of the Federal government than the universities. In general, universities do not set priorities for research; rather, their priorities are a function of the Federal research funds available. Since almost no Federal monies (except a small amount from the National Science Foundation) are available to support study and research related to manufacturing technology, the universities have essentially ignored this area. Were Federal funding patterns to change, the vitality of manufacturing research and education would improve quickly.

Question: How does the vitality of manufacturing research and education compare with other engineering disciplines (for example, electrical, aeronautical, and chemical)?

Answer. The second question concerns the lack of closer ties between industries and the university research community. We believe that industry-university ties are closer in the U.S. than in any other country. This is not to say, however, that they could not become closer or more productive in this country; but rather, that the barriers to such cooperation are relative minor. S. 1286 might help overcome the barriers that do exist, but it will not accomplish a great deal along these lines. If one wants to establish closer industry-university ties, there are more effective ways to do so. The most straightforward and effective program we are aware of is one in Israel. In general, the Israeli government will pay one-half the cost of private R&D aimed at the development of new products that will improve the country's export position. When an Israeli firm contracts with an Israeli university to do such R&D, the government will pay two-thirds of the cost. This has proved to be a powerful incentive for cooperation. Of course, this program is aimed at increasing Israeli exports, but its operating mechanism has the effect of improving industry-university cooperation as well.

In the U.S. context, a similar statement might be made about the industrial extension programs that exist in some states. These programs are primarily concerned with improving industrial productivity, but because they often operate out of universities, they have the additional virtue of bringing university and industry people together. We believe that strengthening programs of this type would be an appropriate way of improving university-industry ties.

Senator GORTON. Let me follow with just one question. We do not know the answer to that, but we do know the answer to what happens if Caterpillar does not make that investment, do we not? Those people will all be out of work?

Mr. HOLLOMON. You all have continuously asked this? I believe, unless our companies become competitive and productive and raise the quality of their products, a lot of people will lose jobs in America.

I do not know who mentioned the problem of structural employment. I believe Senator Riegle did. I think we are already facing the case of how many people will go back to work after this economy gets rolling again because of the structural changes that have occurred in American industry.

Senator **Gorton**. Could I at this point get each of you to comment on something each of you did to a certain extent, and that is the question of education and especially the relationship between education and the choice to make careers in manufacturing technologies. At least two of you have mentioned that at this point.

I would like to ask a question as to whether or not the primary problem seems to be a lack of interest on the part of bright, potential students in this field, both the field of engineering overall, and especially the field of manufacturing technology, or is it a perceived lack of opportunities in the private sector, or is it the inability of many educational institutions to provide the kind of education which would be productive in directing bright people into this general area?

Mr. **Ansell**. Senator, it is all of those. The problem in attracting bright young people into manufacturing is not the same as attracting them to make a career choice in engineering. On the one hand, there is a record number of young people entering engineering colleges today. Almost twice as many young people are graduating from engineering schools now as there were 5 years ago.

Almost half a million young people are now enrolled in university and college engineering programs. However, very few of them are enrolled in manufacturing curricula. Indeed, very few universities have any formal educational program in manufacturing. While the basis for this situation is complex, I believe that some of the reasons for this state of affairs are as follows.

One, there has been a perceived lack of opportunity in manufacturing as either an interesting or a dymanic field. Our image of the manufacturing factory is that of a dirty, smelly, cold place—an image of a place to try to escape from and not to enter. It is not viewed as an attractive environment. Many of the parents of these young people grew up in that environment and want their children out of it. That is not the manufacturing image that can remain if we are to succeed, but that is the image that has remained.

In addition there are no manufacturing role models on the university campuses. In order to keep faculty alive and vital, and at the forefront of their field, they must do research.

While there is a lot of engineering research ongoing in the Nation's universities, almost none has focussed on manufacturing. The basic engineering sciences are supported by the National Science Foundation. Additionally, the Federal mission agencies support a lot of research. As a result, university engineering research in this country focusses very heavily on basic engineering science and those technologies which are of interest to the mission agency.

But there is no U.S. mission agency whose primary interest is manufacturing. As a result, both faculty and students are attracted to those fields in which there is a major research support. This is where the action is. Where there are interesting things going on, on the campus itself. In manufacturing, there has been little going on, on the campus, to attract or interest either faculty or students.

Last, we did an interesting experiment. Rensselaer some 7 years ago started a major program in manufacturing. It was one of the few schools, along with the two others who are represented here today, who have active and vital manufacturing programs. We worried about the same issue you did, why students would not go into manufacturing.

We tested the problem. We asked a young student in electrical engineering who was about to graduate, and who had a 3.9 average out of a possible 4.0, as he went interviewing for a job, to tell the interviewer he was interested in a manufacturing career. In the interview, an interview with one of the major U.S. manufacturing corporations, the interviewer told the young student he should not go into manufacturing. He was too bright for a manufacturing career, he should look to design or sales. That is the image of manufacturing, an image held until very recently.

Our students saw no excitement in manufacturing career. Manufacturing industries also saw no challenge or excitement. That is why there has been relatively low capital investment in manufacturing and why there has been very little interest or movement of young people into that profession. This is the situation we now have to overcome.

This situation is now changing slowly. Ordinarily, when new technologies develop, you can afford to enter them slowly and grow in a mature, reasonable way. But we are not entering a marketplace in which we are talking about a new technology. We are talking about a marketplace in which our competitors have been developing this technology, utilizing it, and bringing manpower in for 30 years.

We are now playing catchup. In Rensselaer's manufacturing program we do research for companies. The purpose of this research is to bring on the campus interesting, exciting work for faculty to do and for students to get involved with, so as to motivate some of our best students into manufacturing careers.

Mr. **Hollomon**. So do we. You do it and Carnegie does it and so do a few other schools.

Senator **Gorton**. I am sorry to indicate it, but that last buzzer means we have a vote on the floor of the Senate. Frank, if you have a question I would be happy to permit you to ask it.

Senator **Lautenberg**. It is short.

Senator **Gorton**. In addition to that, we may very well have written questions which we would appreciate your answering for us. Senator Lautenberg.

Senator **Lautenberg**. Thank you very much. Part of the reward of this job is to hear people expert in their field talk about their field, particularly one which is of so much interest to me.

I come from the corporate sector, the private enterprise area. Before I came to the Senate, my business was in computer services and some of the things that have been said in different ways among you really strike home with me.

I think there is one critical issue that suddenly seems to be talked about and that is the lack of the ability of management in companies throughout our society and the necessity to take the blame when something goes wrong. Some of this cannot be settled in the kind of legislation we are talking about here. It relates to technological development.

Dr. Hollomon, I could not agree more with you. Technology is the wrong place to focus. It will not get us the productivity. The productivity will come from how the people who have a responsibility for using the technology use it and is their soul in it?

I beg a minute more. I started to come here with two other fellows 33 years ago. We did not have a dime when I left that company to come into the Senate this past January. We had 16,000 employees throughout the company and it is one of the classics in American enterprise in terms of investment and so forth.

But because we are in the computer industry, there are high multiples paid on earnings and it is very unattractive on a comparative basis to be investing in manufacturing where the growth, though predictable, is really not quite, to use the expression, as sexy as we would like to portray it. And when you can invest, as you might have, in my former company $300 in 1961, it is worth $150,000 today in the marketplace; 23 years later the company is called ADP. That is the kind of thing that turns people on and the humdrum existence of making very good incomes and so forth in manufacturing is not particularly appealing.

You said something, Dr. Ansell, that just struck home to me. My father was a poor workingman. He worked in a factory. He took me by the hand when I was 10 years old in Paterson, N.J., and said smell this place, feel this place, the noise of this place, the light and the heat of this place. This is something you must never, never endure. You must get an education. This was in 1933 or 1934.

One of the things I think we must do is focus on the financial structure in our society that enables managers to protect themselves with golden parachutes and not be subjected to the same pressures the worker is subjected to or an investor is subjected to when he puts his own money on the line and this will, I hope, lead us into other legislative review so that we can deal with the problem of interest by managers getting up to snuff and not protecting themselves, insulating themselves from their public trust and their responsibility.

In sum, I am very concerned about the societal changes. I made a speech on the floor of the Senate, my first speech there 10 days ago, and I talked about what might be the injustice of the computer age in terms of computer literacy and computer illiteracy. I hope you saw it and, if not, we happen to have copies available in abundance. I will autograph them, too, if you would like.

It is a very serious subject, because I come from the State of New Jersey with the third highest per capita income in the country. Three of the poorest cities in the Nation are in that State. Newark, Paterson, my birthplace, and Camden, N.J., are among the poorest cities in the country with per capita incomes, in some cases, around the $3,000 to $4,000 levels.

So, I am concerned about this tiering of our society. The new environment enables those who are gifted with affluence and exposure to move at a pace which leaves the others way behind. We will not have a trained work force to take in the new opportunities.

And manufacturing is an instance where a small investor can make his investment, hire the unskilled, and provide jobs for the cities and urban areas.

Go ahead, we have got a couple of minutes. Dr. Hollomon, you are a distinguished citizen. All of you are, and a contributor.

Mr. **Hollomon**. I would like to make two comments, Mr. Chairman, before I leave. One has to do with—in S. 1286 I find a small deficiency which can easily be changed. I find not enough attention in that bill to questions of work environment, as you mentioned, the business of safety and health in the workplace, how it has to be integrated with technology and management.

I think that is something the committee could address itself to. I believe that for any new technology entering the workplace, one must consider how it impacts upon the working environment as well as the individual worker and I think that is important, an important aspect of the legislation that should be considered.

One other comment about the number of people going into manufacturing engineering. We have done studies of this issue at the center which I directed for the last 10 years, and it appears that the number of people entering education in a given field in engineering is dependent upon what their view of the jobs in that field is. If there are jobs in manufacturing engineering, I believe we will get good people entering. But if there are no jobs, forget it.

Mr. **Ansell**. There are data which refute that. The data derive from the nuclear power industry, an industry in which there is a strong demand for engineers. However, student enrollment is low because of negative parental and student perceptions of the field, similar to the effect of parental perceptions you described for manufacturing.

Before you leave, Senator, this bill is a person bill. It is a relatively small funding bill, $30 million a year. It provides what would essentially be the only Federal funds for supporting research in manufacturing as it affects the civilian sector in the United States. One of the reasons there is very little manufacturing activity in universities is that there is no other major research funding source.

It also accomplishes the further purpose of making a shift, however slight, in the priorities for the Commerce Department of making a focal point in the manufacturing area. This is a very important signal. If that is the intent of the Congress, then this is the way to start.

Thank you.

Senator **Lautenberg**. Thank you very much. I also sit on the Banking Committee and what I said to you earlier about my interest in making sure that management is also responsible for its performance as well as labor is something we will be looking at, because again I think this bill is a very good one. I may cosponsor it. It is a relatively small investment in what our society needs and we always get into the debate of where Government help begins and Government interference ends.

Thank you very much for your testimony and for joining us today. This session is adjourned.

[Whereupon, at 11:55 a.m., the subcommittee adjourned.]

ADDITIONAL ARTICLES, LETTERS, AND STATEMENTS

STATEMENT OF HON. PAUL TSONGAS, U.S. SENATOR FROM MASSACHUSETTS

Mr. Chairman, let me first thank you and Senator Heflin for convening these important hearings and allowing me to testify. I am grateful for the leadership you and the other members of the Committee have shown in addressing the importance of technology development for industrial competitiveness.

I believe the record is clear; technology development has a critical role in promoting industrial competitiveness. It is the key to sustaining the vitality of our emerging high-technology industries. Recent months have seen a burgeoning of public awarnesss of the growing contribution of these industries to our economy. Less obvious perhaps, is the hope technology offers for encouraging innovation and revitalization in our basic industries. The efforts of Professors Abernathy, Clark, and Kantrow in analyzing innovation and competitiveness in the auto industry provide a vivid example of how important innovation is to revitalizing basic industry.

The broad-based bipartisan support for the legislation before the Committee, S. 1286, S. 632, and S. 428, makes it equally clear that the Federal government has a critical role to play in promoting technology development. In particular, all of these bills make clear that we need to give special attention to research and development relevant to industry.

As the sponsor of S. 428 and cosponsor of S. 1286 I obviously support the legislation before the Committee. Today, I would just like to emphasize two points which I would hope to see addressed in any legislation approved by the Committee.

First, I believe it is imperative that we provide for a comprehensive comparative analysis of our industrial research and development efforts relative to those of our major industrial competitors. The growth of targeted technology development programs in other countries like Japan, France, and others, raises serious competitive concerns for our economy.

While there may be debate over appropriate actions to take in response to their efforts, I think we should all be able to agree, we should know where we stand.

The most far reaching comparative effort I know of was conducted last year by Japan's Society of Science, Technology and Economics. Their study concluded that Japan was inferior to the United States in 56 key technologies, and superior in 51. (The report was cited in last month's six part Washington Post story, entitled High Tech: Leaving Home. I have provided a copy for the Committee to use as it sees fit). I am not endorsing the conclusions of their study. I do believe nothing could be more short-sighted than our failure to take stock of our current position.

A case in point of how we may be falling behind in technologies of strategic economic importance is provided by the GTE Corporation in its testimony regarding its efforts to do advanced ceramic development for potential application to combustion engine design. It appears that U.S. support for ceramic development has been curtailed at the same time efforts have expanded in Japan and other countries. Setting appropriate policy for R&D requires a reliable comparative assessment. That is simply a fact of life for competing successfully in the increasingly competitive international market place.

The second point I would like to make is the importance of building a process for moving ahead with key manufacturing or economically strategic technologies. The recent widespread criticism over the Administration's decision to create a new National Center for Advanced Materials at Lawrence Berkeley Laboratory has been brought to the attention of the Committee during these hearings. Utilizing the judgment of advisory groups composed of those researchers closest to the development problems will help avoid criticisms like this.

It is critical that such advisory groups made up of industry and academic representatives be involved in formulating recommendations for moving ahead with economically strategic technologies. Such a process will maximize the prospects of developing plans which encourage participation between academia and industry, promote cost sharing between government and industry, and build consensus on necessary actions. Finally, and perhaps most importantly, such a process avoids the presumption of what the government role should be, or the role of any of the participants. Those closest to the problem are best situated to recommend roles that are the most workable.

Again, I thank the members of the Committee for this opportunity. I look forward to helping you in whatever way I can in moving forward with this important legislation.

STATEMENT OF LEWIS M. BRANSCOMB, VICE PRESIDENT & CHIEF SCIENTIST, INTERNATIONAL BUSINESS MACHINES CORP.

My name is Lewis M. Branscomb. I am Vice President and Chief Scientist of the IBM Corporation and am submitting this testimony in that capacity. I formerly served as Director of the National Bureau of Standards and am currently Chairman of the National Science Board, the policy-making body of the National Science Foundation. I am testifying here as a scientist with considerable experience in university research and teaching, government research management and industrial research and technology management, but I am not speaking officially on behalf of the National Science Board.

Any strategy for getting the U.S. economy moving again must take into account the unique leverage that scientific and technological capability have on economic competitiveness. Many other factors are influential: the cost and availability of capital, the regulatory environment for industry, the size and availability of markets. But whatever the financial and regulatory environment, the victory ultimately will go to those countries and enterprises that can deliver to their customers goods and services of the highest quality, lowest cost and most appropriate function. Function and quality are delivered by technological innovation; cost and quality are matters of technological productivity. Technology is the key to both. The United States has a strong base in science and an excellent record for innovation. Where we are most severely challenged, particularly by the Japanese, is in productivity, for Japanese firms focus their strategy on their manufacturing technology and organizational performance.

Any strategy for getting the U.S. economy moving again through science and technology must embrace three interrelated elements:

1. The competitiveness of the technology in both manufacturing and development in our commercial enterprises.
2. The vitality of the nation's basic research enterprise.
3. And the quality and abundance of properly educated human resources, both in critical professions and in technological literacy of the entire work force and the consuming population.

There is widespread concern in America that these roots of our economic prosperity have been neglected. The American people are eager for the rebuilding process to accelerate.

If the Federal government is to stimulate rather than obstruct this rebuilding, it will require actions in the Congress and Executive based on consistent and well-defined views of the relationship between public policy, education, research, technology and economic health.

In developing this strategy two pitfalls must be avoided: the temptation to boil the ocean and the search for the golden arrow, to borrow two phrases used in our industry. We cannot expect the Federal government to attempt to fix every deficiency in our educational system and our economic performance, both because the costs are unaffordable and because massive interventions have not proved efficacious in the past. The Federal government should leave the development of commercial technologies that must be driven by astute market judgments to the private sector. Some advocates of a new "industrial policy" seem to me close to falling into this trap of attempting to boil the ocean.

Equally doomed to failure will be the golden arrow strategy, which I will caricature as the attempt to develop in every community in America a laboratory for building computer chips and for carrying out genetic engineering. The "high tech" industries are vital to a strong national strategy, but their role is to provide the tools, knowledge and capabilities that can increase productivity and innovation in every sector of American life. We need not only high tech industries to compete internationally; we need high tech farms, high tech appliances, high tech automobiles, high tech steel.

In short, every area of our economic life must become "high tech," thus benefitting from modern productivity enhancing tools, an educated work force and imaginative, quality oriented, competitive management. Computers, communications, information services, genetically improved natural products, high yielding seeds and more powerful, less expensive pharmaceuticals can, along with other technologies born of new science, work magic in the American economy if we strengthen our research and education system, encourage innovation and productivity increasing investments in the private sector and reduce constraints to innovations and growth.

The starting point for such a strategy is the financial environment within which industry makes its R&D decisions. Many of the high technology compaines are among those paying taxes at the highest rates. The research and development incentive tax credit is an important element in balancing the tax burden on our high technology businesses as compared with other profitable industries. While it is still early in the life of the tax credit to prove with hard data that it has had the leverage expected, there is no doubt that in my industry the response to the tax credit has been strong. My own company spend $3 billion in 1982 on research, development, and engineering—a 24 percent increase over 1981, and in the first quarter of 1983 we invested 20 percent more in R&D than in the corresponding quarter of 1982. The 1982 annual reports of our competitors show that most of them, including several whose earnings were substantially down from the previous year, have done the same thing.

I commend the Senate for taking under consideration making permanent the incentives that led to that doubling of R&D growth rate, and for taking that action now so that the financial aspects can be considered for R&D efforts beyond 1985 when the major expenditures will occur on new projects for which research commitments must be made today. Other R&D provisions, especially those that provide additional incentive to private industry to help our universities refurbish their equipment and bring their research interests closer to the leading edge of industry, also deserve support.

Thus, IBM supports Senate measure S. 738, which would make permanent the tax credit for increasing research activity; S. 654, which would permit the deduction of all research and experimentation expenditures against U.S. source income for research conducted in the U.S.; and S. 1194 and S. 1195, in concept, which would promote contributions of scientific equipment to our schools and foster university research. All are significant contributions to the environment for responding to a highly competitive international marketplace in technologically sensitive industries.

Now let me turn to education and research, for this is the sphere in which the Federal government has the greatest responsibility and must address some serious issues.

For reasons of brevity, I will not focus here on the precollege education issue. The need for a national rejuvenation of mathematics and science instruction in our schools is perhaps the most widely discussed education issue in our nation today. The National Science Board has a very distinguished commission of citizens completing their work this summer on action plans to address this issue. Let me turn, instead, to some equally important but less often discussed questions that lie closer in time in their influence on our economic performance.

The roots of all commercial technological capability are in the people and ideas that come from our colleges and universities. Industry has substantially stepped up its activities in collaboration with, and in support of, education and research in the universities. My own company has some 530 research projects with 180 universities. A few of these projects are major in scope: a major joint development effort with Carnegie-Mellon University of an entirely new kind of distributed computing environment; a major development of the diagnostic tool of the future in medicine—the nuclear magnetic resonance imaging system—carried out for us by MIT; a new project recently announced at MIT on new ways to use computers in scientific, engineering and business education.

The most productive industrial operations, those most susceptible to automation, involve materials and processes that come from brand new discoveries in science. Indeed, some of them exhibit properties not yet understood by science, even as they are used in the factory. Thus, dependence of industrial technology on leading edge science is increasingly acute.

By the same token, modern science owes an increasing debt to the latest in technology, for technology provides the tools needed by an ever more sophisticated science.

Thus, in our own self-interest, industry must and will collaborate with the universities to provide them such help as we can, share with them our most exciting problems and provide their faculty and students with insight into careers of the future in the private sector. In the process, we can convey to the universities the need for rapid response on their part to the extraordinary pace of change in industry, which calls for new university capabilities. I will, in a few moments, describe a specific example in the area of manufacturing systems technology, where IBM has offered $50 million in assistance to universities that wish to redirect their efforts in this area.

The need for Federal involvement in this rapidly changing situation derives from the pace of change itself, to which our universities cannot rapidly respond without major help, and from the scale of our national educational and research activity which far transcends the resources of the private sector to sustain.

From all parts of the U.S. political spectrum, there is agreement that the Federal government must sustain the basic research and graduate education capabilities of our universities in the most critical fields of mathematics, science and engineering. Even with expanded effort, industry can contribute only a small percent to the total costs of our great research universities.

What are the specific changes most urgently needed in our university research and education system?

First is the importance of resuming real growth in our long range fundamental research enterprise, a growth that, in the physical sciences and engineering, has been requested by the President in the 1984 budget. After nearly a decade of little or no real growth, a sustained effort over a period of time will be needed to revitalize and modernize this world-leading research capability on which all our future strength depends.

This is an area in which the Federal government must take the initiative to support and encourage private industry support to upgrade obsolete research facilities and equipment in the universities.

A second issue results from severe supply and demand distortions in Ph.D-level scientists and engineers, and other skill levels as well, that have resulted from the inability of universities to respond to rapid changes in the skill mix required by industry. Here, computer science and electrical engineering represent specifically glaring examples, but we will find others in plant biology, microbiology, chemical engineering and a variety of fields.

The solution requires expansion of university faculties in these areas which, in turn, requires fellowship support for students and equipment and research support for young faculty so that university careers in these critical fields can again be as professionally attractive as research careers in industry. Private industry must play a role. For example, the IBM Corporation has recently initiated a Faculty Development Awards Program through which we will assist universities in attracting and retaining outstanding young faculty. These 50 annual two-year grants, each totaling $60,000, will help selected untenured faculty to establish themselves by gaining more released time from teaching for research, and to obtain resources and equipment for that reseach. However, the Federal government must expand its funding in this area also.

The third area of modernization urgently needed in our universities is engineering education which relates directly to U.S. industrial productivity.

For three decades, American engineering schools have concentrated on strengthening the scientific base of the engineering curriculum and have motivated young engineers to pursue careers in research and development. This is an important goal, and it has been successfully achieved. In the process, however, we seem to have forgotten that the modern factory offers some of the most challenging and rewarding high technology career opportunities for engineers. In reality, the factory in America has fallen in the public esteem and is not generally regarded as an institution offering technical challenges worthy of the best students. This condition must be reversed without sacrifice of the scientific sophistication of American engineering or a reduction in emphasis on originality and creativity. This is the area where swift action to assist universities, involving participation of both Federal agencies and private industry, could reap great rewards for our economy in responding to overseas competitive challenges, particularly from Japan. For the secret to the Japanese success is their manufacturing engineering skill, the quality and cost of their production.

Fortunately, the new computer and robotics technologies used in high technology manufacturing plants are attracting young engineers back to questions of designing products for ease of manufacture and technologies and systems for efficient production.

Overnight, there has been a change in attitude in the schools of engineering, most of which are now ready to develop stronger curricula and expand research in areas that will contribute directly and immediately to the productivity of American industry.

When IBM announced last September that we would provide $50 million in cash and equipment gifts to selected engineering schools interested in developing programs in manufacturing engineering and design for manfacturability, we thought we would be fortunate to have 25 or 30 serious responses.

In fact, 162 schools responded with proposals for the initial planning grants we offered. We will, in fact, be able to assist approximately five institutions with funds for curiculum and program development, and perhaps as many as 20 with equipment grants in computer aided design and manufacturing. The great majority of the schools will have to look elsewhere to implement the plans they are making.

The President's National Productivity Advisory Committee, for which I chair the Subcommittee on Research, Development and Technological Innovation, recommended in December to Cabinet councils and the President that a matching grant program be established by an appropriate Federal agency to stimulate private sector contributions to engineering schools to strengthen this area of our national capability.

Section 5 of Senator Gorton's bill, S. 1286, the Manufacturing Sciences and Technology Research and Development Act of 1983, is directly responsive to these needs. This legislation would provide for research on more efficient manufacturing processes and methods as well as providing an opportunity for NSF and Commerce to work cooperatively with the private sector to stimulate science, engineering and research. In addition, Sections 6, 7 and 8, which provide for the evaluation of the most feasible means of enhancing the introduction of advanced manufacturing methods, the analysis of specific industrial sectors' long-term capability for remaining competitive and the provision for an advisory committee, are necessary to insure Section 5 grants are effectively utilized.

Although the bill focuses on research, I believe that if this research is carried out in our university engineering schools it can have crucially needed edcucational benefits as well.

Perhaps the Centers for Research and Technology will be the strongest part of the proposal. They are desirable because needed technology work can be advanced only a little by individual investigators; interdisciplinary teams are needed, and academic and industrial people should participate.

While much of what this bill envisions could be carried out under the authority of the National Science Foundation, I believe it is entirely appropriate and wise that the Commerce Department be urged to undertake this mission. Together with the NSF's focus on the more scientific elements of engineering, the two agencies together could broaden the base of support for the modernization of our academic engineering capability. In addition, the Department of Commerce, with its stronger connections to industry, is likely to manage such a program with a proper eye to industrial priorities and a proper sensitivity to the boundary between the long range research appropriate for Federal activity and the more proprietary process research that should be left to the private sector.

Thank you.

STATEMENT OF THE BUSINESS-HIGHER EDUCATION FORUM

The Business-Higher Education Forum is an organization of chief executives of more than 80 leading American corporations and colleges and universities. The group, founded in 1978 in affiliation with the American Council on Education, promotes discourse and acts on issues of mutual interest to America's business and higher education institutions.

As part of our prepared statement, we would like to add to the record a copy of the report which the Forum sent to President Reagan on May 16, 1983. The report is entitled, "America's Competitive Challenge: The Need for a National Response."

The purposes of our testimony is to brief you on the findings of our report. While we will try to emphasize the role of technological innovation in enhancing our national competitiveness, it should be emphasized at the outset that technological innovation is only one element in the competitive picture and must be considered within the broader context of our overall competitiveness.

Briefly, our report found that the performance of the U.S. economy is keeping pace with neither its own past achievements nor the current performance of other industrialized nations. While the U.S. economy has remained relatively stagnent in recent years, countries such as Germany, France, Italy, the United Kingdom and Japan have made rapid gains—measured both in terms of productivity growth rates and comparative market shares.

As a result, today we have an annual trade deficit of about $35 billion in markets for non-R&D-intensive products, such as autos and steel, compared to a zero trade balance in 1960. Even more significantly, these foreign countries have targeted and have captured major world market shares in the rapidly growing, high-technology and service industries of the future, such as computers, telecommunications, advanced electronics, biotechnology, aerospace, insurance and financing. In the past decade alone, the U.S. share of world exports of both high-technology products and service industries has declined from 25 to 20 percent.

In preparing the report, the Business-Higher Education Forum tried to answer the central question: why is our competitiveness declining? Here we were faced with a paradox.

A nation's ability to compete depends on the vitality of three primary, interactive and interdependent elements: productive capital investment; technological innovation, ranging from basic research to the commercialization of new products and processes; and skilled workers. Despite the fact that we have the world's largest capital base, the world's most advanced technology, and a highly educated and skilled work force, we found disturbing evidence that the United States is falling behind precisely because we are failing to fully utilize these strengths.

Let us pinpoint the major trouble spots, concentrating on the one of most concern to your subcommittee—technological innovation.

Technological innovation has long been a major contributor to the nation's productivity growth, and hence our ability to compete. Yet in the two key stages of technological innovation—the generation of new technology and the commercial introduction and use of new technology—disturbing trends are emerging. There is growing evidence that the United States is falling behind competitively—not in inventiveness, but in the commercial application of scientific discoveries and technological advances.

The problem is not one of gross expenditures. In 1979, the last year for which comparable data are available, private funding for R&D in the U.S. (about $26 billion) was about equal to the amount spent by firms in Japan, France and West Germany combined. In that same year, the U.S. government's R&D expenditures (about $27 billion) were almost half again as great as those of the Japanese, French and West German governments combined.

Rather, we found the problem centers on the allocation and use of R&D funds. Since 1960, the proportion of industrially funded R&D devoted to basic research fell from 8 percent to 4 percent. Much of that research—which is necessary for major breakthroughs and sustained productivity improvements—was redirected to short-term objectives. In some industries, this shift was in response to health, safety, environmental and other regulatory requirements. At the same time, American universities—which conduct more than half the nation's basic research—have suffered from an accumulated underinvestment in facilities and equipment amounting to an estimated $1-4 billion.

Thus, after more than a decade of tight budgets, universities increasingly are being asked to conduct pioneering research with obsolete equipment in run-down facilities. The severity of the problem already has caused the productivity of university research to decline.

Advances in manufacturing technology have been an important element in the increased competitiveness of Japan and Western Europe in such industries as automobiles, aircraft and agricultural machinery. In the United States, however, it appears that the level of investment in manufacturing technology has, until recently, been quite low. Furthermore, unlike their foreign counterparts, U.S. companies are discouraged by antitrust policy from cooperating on R&D.

Federal R&D spending also plays an important role. The U.S. government spends substantially less than governments of other industrialized nations on projects to stimulate industrial development and growth. While other countries spend between 10-15 percent of their R&D for such purposes, the U.S. government spends less than 1 percent. Instead, more than two-thirds of federal R&D monies are allocated to defense and space projects, and thus make a smaller direct contribution to productivity than would expenditures specifically for commercial projects.

Although significant business-university R&D partnerships have developed recently—and the Business-Higher Education Forum is a dramatic demonstration of the cooperative relationship between the two sectors—we found, nonetheless, that technology transfers between government and industry and between universities and industry remain weak overall. These transfers must be strengthened if we are to improve R&D's actual contribution to our economic competitiveness, which occurs only when new products and processes move off the drawing board and onto the shelf.

Finally, our report found that many government policies delay commercialization, creating higher costs and lost market shares. Poorly timed regulations, contested patents, and the slow resolution of disputes all contribute to delays in the application of technological innovations. For instance, it now takes an average of nine years following discovery before a new drug is approved for sale in the United States; thus new pharmaceuticals discovered and developed by American companies are almost without exception introduced first abroad. Similarly, environmental and land-use regulations have increased the time required to build a new electric generating plant by more than five years since 1970.

We also found disturbing trends in the other two elements of competitiveness. Historically, capital investment has been a major contributor to U.S. productivity growth, but for more than a decade, production-related capital investment has been declining as a percent of GNP. Much of the spending went to non-productive uses, such as meeting regulatory requirements and capitalizing interest payments to cover the costs of increasing delays caused by those regulations.

As a result, two of our principal competitors—Japan and West Germany—now make greater efforts in capital investment as a portion of their GNPs than does the United States.

Needless to say, human resources are essential ingredients in the process of technological innovation and economic competitiveness. Yet, as a number of recent studies—including ours—have pointed out, there are increasing signs that the current and future American work force is inadequately prepared for the competitive challenge.

Shortages already are developing in critical skills, such as computer science and engineering, creating bidding wars for people educated and trained to meet today's needs. One in every five American workers is functionally illiterate, unable to participate in even entry-level training. And there is growing evidence that many American workers lack fundamental skills, in math, science, critical thinking and verbal expression—primarily because of a shortage of well-trained faculty in the public schools.

The challenges of the next decade will be immense. An additional 15 million new workers will enter the work force. They—and many of the 100 million currently employed—will need education, training and retraining to keep abreast of changing job needs. Today, U.S. institutions are inadequately prepared for this important challenge.

While a number of factors contributed to the weakened vitality of the three areas just outlined, the Forum focused on three: disordered public policymaking, which has produced fragmented, often contradictory policies and created a virtual gridlock at all government levels; inflexible public and private institutions—government, business, education and labor—which have failed to respond to the new economic realities of global competition; and a failure to use our vast information-processing tools to consolidate and harness information and knowledge for productive action.

In appendices to our report, we inventoried more than 200 policy proposals on technological innovation that have been made in the past two decades. For many of the reasons just enumerated, most have not been even systematically evaluated, let alone implemented. Most have been ignored. They stand as a monument to the well-intentioned failure of our nation to come to grips with the international economic challenge.

Thus, we at the Forum believe additional, specific recommendations are not the primary requirement at this point. Rather, we must enhance the ability of government to act on the proposals it receives. In short, the fundamental step must be to develop a national consensus that industrial competitiveness in international markets is crucial to our social and economic well-being.

Our primary recommendations to President Reagan—a major address on the competitive challenge, the appointment of a White House Adviser on Economic Competitiveness, the establishment of a private-sector National Commission on Industrial Competitiveness, and the creation of an Information Center on International Competitiveness—were designed to elevate the competitive challenge to the top of the national agenda.

The American public and their elected officials must recognize that unless we improve our ability to compete, and unless we develop a comprehensive, coherent, long-term approach for competing in this new world—where trade now accounts for 25 percent of our GNP—we fear that the full revitalization of the domestic economy will not occur. And unless we rebuild the American economy and strengthen our educational system, it will be increasingly difficult—if not impossible—to maintain a just society, a high standard of living for all Americans and a strong national defense.

Similarly, all of us must recognize that we must avoid the twin pitfalls of protectionism and increased government intervention into the activities of the private sector. Our mandate must not be to punish or retard the competitive gains made by other nations, but to do a better job of competing ourselves. And government's role must be to streamline its own processes and create a climate—through public policies in the areas of taxation, trade, antitrust, patents, regulations, among others—in which the individual and collective talents of the private sector can be focused to meet the competitive challenge.

We believe that achieving the basic consensus on the importance of economic competitiveness will help you on the Subcommittee take the necessary steps to revise technology innovation policy, for instance. Just as it will help the Education and Labor Committee play its part. Just as it will help us in the private sector undertake the needed changes in our own universities and corporations.

One of the fundamental challenges facing all of us is to ensure that we strengthen all three elements of competitiveness—capital investment, technological innovation, and the American work force—simultaneously. For example, continuing to spend more on R&D than any other nation in the world will have little impact on economic growth unless changes are made to help American industry successfully commercialize the results of that R&D. At the same time, a massive investment in new factories and state-of-the-art equipment will accomplish little unless a corresponding investment is made to develop a newly skilled and competitive labor pool.

The three areas are so closely interdependent that benefits will come only if we deal with the problem in its totality—through a coherent, comprehensive national response to the competitive challenge.

There are no shortcuts. There are no "quick fixes." While the current economic recovery is welcome, we should not let it mask the fact that many of our economic problems are deeprooted and structural, caused by years of benign neglect and institutional inflexibility on the part of all sectors. For too long, we have taken our competitiveness for granted. If our report serves no other purpose, the Forum hopes it convinces the American people and their public officials that we must reverse that outmoded perspective.

While our report and these remarks speak to problems and concerns, it would be wrong to conclude that we at the Forum were stimulated only by the negative aspects of our national problems. Indeed, it is our very strengths in the basic sciences and the opportunities these advances offer that have been most stimulating to the Task Force. Following World War II, our nation decided to give a major part of the responsibility for basic research to the universities. Their performance has been superb. Today we have unprecedented opportunities in biology, in high energy physics, in the cognitive sciences, in information transfer and in many other areas to apply new knowledge to the benefit of all.

Thus, far from gloomy, we at the Business-Higher Education Form are optimistic.

We ended our letter to President Reagan with the following thoughts, which we would like to share with you:

We stand at the hinge of history, with an unprecedented opportunity to combine the lessons of our past with the resources of our future to revitalize the economy, create more jobs, and increase the standard of living.

As a nation, we have the tools: a rich knowledge base; an energetic and creative people; a flexible form of democratic government; and a wealth of scientific advances and technological breakthroughs waiting only to be put to productive use. Indeed, the richness and diversity of our resources imbues us with a special responsibility to utilize them for the good of not only our own citizens, but for all mankind.

The task will not be easy. It will call for institutional change as well as technological innovation. We must operate from a new worldwide perspective. We must find new approaches and forge new partnerships for coordinated action. Above all, we need a focused national commitment. We must start now.

Again, thank you for inviting the Business-Higher Education Forum to participate in these hearings.

STATEMENT OF F. JOSEPH REID, DIRECTOR, MATERIALS SCIENCE LABORATORY, GTE LABORATORIES, INC.

Silicon nitride is a high performance ceramic material which is not found in nature but is readily synthesized by modern manufacturing methods. It has a number of properties which make it unusual among ceramic materials. Silicon nitride is tough, strong, and has very good resistance to oxidation and thermal shock. Because of this important combination of properties, this material is receiving world wide R&D emphasis to develop it for a number of applications (e.g., advanced automotive engines and metal cutting tools).

GTE has been working on silicon nitride since 1972 and has accumulated more than 60 staff years of direct experience through Corporate research expenditures exceeding 12 million dollars plus 1.3 million dollars of government support. The result is a vertically integrated manufacturing capability which includes: manufacture of silicon nitride powder, R&D on basic silicon nitride alloy materials, near-net-shape technologies required for the production of complex parts, such as those for gas turbine engines and R&D in non-destructive evaluation methodologies required for process control and inspection of finished parts. Properties of the GTE silicon nitride materials are state-of-the-art which has qualified GTE for participation in ceramic engine development programs sponsored by the Department of Energy and the Detroit Diesel Allison Division of General Motors. It is with the perspective of materials development and manufacturing, that we deliver this case study in which silicon nitride ceramics will be used as our example.

There are a number of near-term applications for silicon nitride, which include: metal cutting tools, high speed bearings, and a variety of wear applications. The technology to meet these near-term markets exists. Much of this technology was developed with GTE Corporate research funds. For example, GTE developed a manufacturing process for producing a silicon nitride powder of extremely high purity which has become a recognized standard throughout the world; GTE alloys made from this powder possess exceptional high temperature strength and oxidation resistance. GTE has developed unique ceramic-ceramic composites that provide exceptional wear resistance and toughness; these composites can be used to manufacture cutting tool inserts which can yield an order of magnitude greater productivity in cast iron machining than conventional cemented carbide or aluminum oxide materials. Developing these technologies was risky, but in spite of the fact that overseas competitors enjoy governmental subsidy, GTE took this risk because the markets for these products exist. The market for cutting tools will develop slowly because high speed, high horsepower machines not widely available are needed to take full advantage of this productivity potential; their installation will now be driven by the availability of the GTE cutting tool. GTE strongly believes that this development will play a roll in the rejuvenation of American industry.

A key, longer term application for this material is in advanced heat engines, for example the adiabatic diesel and the gas turbine. Potential fuel efficiency increases of 30 to 40% can be achieved in these engines but only with the use of ceramics, such as silicon nitride, to resist the engine's increased operating temperature, temperatures at which structural metal alloys fail. The successful use of ceramics in prototype engines has been demonstrated by the DOE programs and military applications have been demonstrated by DOD programs. For commercialization however, these structural ceramic materials must be made cost effective and more reliable. High volume, low cost manufacturing processes are necessary for such commercialization, e.g., injection molding and sintering technologies. These are expensive development efforts, long-term and high risk.

The engine companies are justifiably hesitant to develop engines without the ceramic materials available in production quantities. The ceramic manufacturers are disinclined to develop the volume manufacturing technologies for required materials and shape fabrication to service only a prototype market. Both are blocked by the investment needed for a long term market development vs. more immediate capital needs for current markets. This condition prevails worldwide. The governments of major industrialized nations, notably Japan and West Germany, are subsidizing engine development programs and research and development of advanced ceramic materials such as silicon nitride for heat engine applications. These government programs intend to defend and extend viability of their economies which are heavily influenced by the auto industry.

Thus, development if these high performance ceramics allows development of advanced engines which in turn allow: increased fuel conservation and multifuel capacity (e.g. methanol or fuels derived from coal or oil shale, powdered coal etc.). The engines would not require the use of superalloys and thus no strategic materials are involved. The development would also defend the U.S. auto industry against further incursions of imported cars. It is for these reasons that high performance ceramics may be considered one of a number of "economic strategic materials". A recent analysis by Argonne National Labs indicates that the cumulative impact over the twenty year period 1985 to 2005 of a US dominant position in advanced ceramics could add $266 billion to the nation's GNP and generate a peak addition of some 250,000 jobs. The alternative, a Japanese dominant position in ceramics would account for a cumulative loss of approximately $110 billion dollars over the same period. Projections of this kind are always difficult, and the assumptions can be questioned. It is a fact however, that the governments of major industrialized nations world wide are subsidizing the development of these advanced ceramic materials. This certainly indicates the perceived importance.

The ceramics development situation has a direct analogy in the development of superalloy materials for aircraft jet engines. The investment vs. market potential was not favorable to expect that the complete technology would be funded by the metals industry. In the case of superalloys, extensive front end R&D was required to develop them to the point that they could be considered engineering materials. This was accomplished with considerable government sponsored research and development. Military sponsorship continues today. As a result of this materials capability, developed with government support, the United States now has a dominant balance of trade position in the aircraft engine market. This situation exists because of the up-stream superalloy technology development supported by our Federal agencies.

The level of technology support for high performance ceramics and its continuity has varied greatly among countries. Work was begun in England in the early 1960's. It has not been sustained and now they are not a force in the development of high performance ceramics. The U.S. programs have made impressive strides through the 1970's. But since the late 1970's the government programs have been characterized by an unsustained funding commitment. The late entry by the Japanese, building primarily on the U.S. programs, is characterized by a rapid increase in funding.

The Japanese have targeted ceramics as a key technology for their future industrial growth. Accordingly they have established aggressive industry/government/university programs. They include a focused R&D effort to fundamentally understand these ceramic materials and engine development programs to ensure their successful application with high reliability to advanced engine designs. It is instructive to compare U.S. and Japanese government funding lievels. The U.S. R&D expenditure on advanced gas turbine engines which includes structural ceramic technology was approximately $23 million for fiscal year 1982. The Japanese programs are broken into basic R&D programs (Fine Ceramics) funded at $122 million over 10 years half of which is government funds and engine demonstration programs (Moonlight) funded at $95 million over 7 years. One point is critical in this comparision. The Japanese programs involve longer range planning: seven or ten years vs. the one year committment cycle for U.S. programs.

From a national perspective, the U.S. ceramic manufacturers are now competing in a world market. The pace of advanced ceramic materials technology development is rapid and accelerating. Other countries are pursuing this goal with long term planning, substantial funding, and a pooling of government, industrial and university resources. In these programs, the problem is centrally directed, with each participant responsible for progress in one area of technology so that in total, they have broader coverage through less overlap. In the United States, each ceramic manufacturer pursues technology development as required to produce engine hardware to meet contractural requirements. Duplication can and does exist.

GTE, as one member of the high technology ceramics community, finds itself faced with a dilemma common to the industry. Corporate funds have been invested to develop a significant background technology. Yet, there is a perceived need to extend that technology into new, long term, high risk applications: heat engines in this case history. Corporate funding for such a proposition may be an unacceptable risk relative to the presently identified market opportunity, e.g. cutting tools and wear parts. A partner is needed. Two options exist: Government or industry partnership. Historically the U.S. Government has not been a consistent partner in these engine development and ceramic technology programs. Working in limited partnerships with other US industries is a consideration but also poses problems: anti-trust considerations and protection of proprietary positions are important factors, particularly in our economy. Other concerns are: the title to patents issued in the course of the contracted technology development and the licensing of background patents or technology to competitors. An equitable balance has to be established between protection of the industries' rights to their own, previously developed technology and the government's requirement for a fair return for their research dollar.

This is the type of program that the Government should be involved in. It is an "upstream" technology, one in which the benefits will accrue broadly across the GNP. It is high risk and long term, involving complex mulit-disciplinary technical problems. For this reason the ceramics industry cannot and will not bear the full R&D cost. U.S. industry needs an effective partner to maintain its dominant position in high technology ceramics for heat engines. Coordination of effort, long range planning and particularly a sustained Federal funding commitment are important considerations in this partnership.

In FY 83/84 new Federally sponsored initiatives have been proposed to strengthen national development efforts for heat engine ceramics. These programs are to run in concert with continued engine development programs. They are called base technology programs and have as their objective development of ceramic materials to the point that they are considered engineering materials by engine designers. This will be accomplished through a fundamental understanding of material processing technologies needed to produce ceramics with highly reproducible properties so they may operate reliably in heat engines. This is an important step. These programs should ultimately be extended through manufacturing technology development to ensure success of National Commercialization.

STATEMENT OF WILLIAM R. SEELBACH, PRESIDENT, CLEVELAND TOMORROW

The purpose of this testimony is to express our strong support for Senate Bill 1286, which is to provide funding for university-industry research in manufacturing technology. I would also ask that you make this testimony an official part of the hearing record.

I am currently President of Cleveland Tomorrow, a committee of 38 chief executive officers representing Greater Cleveland's business leadership. This committee was organized a year ago to pursue a number of programs to help revitalize our region's economy. Exhibit 1 summarizes the programs.

Cleveland Tomorrow strongly believes in the potential for revitalizing and ensuring the competitiveness of our manufacturing base in America by investing in manufacturing technology research. One of our six programs is designed to address this need. It is called the Advanced Integrated Manufacturing Technology Program (AIMTEP). The effort is led by Patrick S. Parker, Chairman of Parker Hannifin Corporation and includes executives from 10 major manufacturing concerns in the region. The purpose of AIMTEP is to improve the competitiveness of local manufacturing firms and to generate new business opportunities through the expansion of Greater Cleveland's technology/knowledge base in manufacturing. AIMTEP will build this technology base by developing nationally emminent and significant applied research and development in integrated manufacturing systems technology through close cooperation between local universities and industry. AIMTEP will also assure high quality education to accelerate technology application and increase the availability of skilled manufacturing engineers, managers and technicians. When fully developed we would expect to see several million dollars of research annually underway in Cleveland area universities supported by government, industry and the universities.

Building this capability will create and preserve employment opportunities in two ways. First, the competitiveness of local companies will improve through the development and application of new technology and the increased supply of high quality people educated in advanced manufacturing methods. Second, additional employment opportunities in new, high growth industries (such as advanced sensors, adaptive controls and image recognition) will be created through the application of and spinoffs from the increased base of applied research.

A Federal program designed to address similar objectives could provide important benefits nationally.

Leverage limited resources—While the need for improved manufacturing technology is great, many of the corporations facing the greatest needs are under severe economic stress owing to the prolonged depression of the domestic manufacturing economy and increased foreign competition. This has limited their ability to make significant investments in longer term technological advancement. A Federal program could leverage these limited resources to provide more critically needed research in this area.

Build university capability—With a few exceptions, most universities nationally have not yet developed outstanding programs in manufacturing technology. High quality university programs require sophisticated laboratory equipment and an investment of time and money to build capabilities sufficient to attract significant industry research money. Federal support of this research could provide critical "seed money" to get programs underway in major technical universities around the country.

Increase visibility of need—A major Federal program in manufacturing technology will attract national attention to the need to develop more industry and university cooperation in this field. This highly visible support could stimulate additional initiatives such as our own.

We appreciate this opportunity to provide our input on this important piece of legislation. If we can be of further assistance to this committee, please let us know.

EXHIBIT 1.—STRATEGY AND PROGRAMS

Overall goal

To undertake basic and effective actions to help assure the long term economic vitality of Greater Cleveland.

Strategy/objectives

To achieve this overall goal, Cleveland Tomorrow developed a three-pronged strategy[1]:

1. Assist "anchor" manufacturing industries, i.e., transportation, machinery, fabricated metals, primary metals, by:

Reducing high unit labor costs caused by above average wage rages, restrictive work rules and a legacy of poor labor management relations.

Improving the region's balance of international trade and sourcing.

Increasing the growth of capital investment.

2. Promote the development of growth industries by:

Strengthening the local technology/knowledge base.

Fostering a more entrepreneurial business environment.

Assuring the long term availability of skilled labor.

3. Address public sector factors contributing to the region's economic vitality by:

Assuring local government fiscal stability.

Organizing and focusing the region's economic development efforts.

Improving the performance (financial and educational) of the Cleveland public school system.

Improving the region's political clout in Columbus and Washington.

Programs

At present Cleveland Tomorrow is pursuing six programs in concert with other organizations to address four of the underlying objectives identified in the overall strategy (reduce unit labor costs, strengthen the local technology/knowledge base, foster a more entrepreneurial environment and improve the region's political clout).

Industry Self Study.—A structured problem-solving process conducted by top management, labor and a neutral third party working with one major industry at a time. Its purpose would be to build a better understanding of the long-term problems of that industry and to develop mutually acceptable solutions and responses.

Work In Northeast Ohio Council.—Cleveland Tomorrow is working with this independent productivity center to foster the application of people-based productivity programs in anchor industry companies. People-based productivity essentially means greater employee involvement in the workplace, tapping and utilizing their knowledge at all levels of the organization, combined with new techniques for managing these human resources.

Advanced Integrated Manufacturing Technology Program.—An initiative to promote increased university, industry and government cooperation to develop advanced technology to improve manufacturing processes. This technology, in turn, would become the foundation for new Cleveland growth industries whose markets initially would be Cleveland companies but eventually would expand throughout the world.

Center for Venture Development.—Cleveland Tomorrow is working with the Council of Smaller Enterprises to create an independent organization to provide high quality consulting services to a limited number of high potential start-up and ongoing enterprises, using in-house staff and community resources.

Cleveland Business Opportunity Fund.—A $10 million for-profit seed and venture capital fund that would provide critical initial financing for promising new and existing ventures in the Greater Cleveland area.

Greater Cleveland Governmental Relations Consortium.—Cleveland Tomorrow is working with The Greater Cleveland Growth Association to establish a coordinated, focused effort to mobilize influential Cleveland people and groups around an agreed-to economic development agenda to gain Washington and Columbus support.

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[1] This three-pronged strategy, and the specific objectives under each strategy, resulted from a sixteen month in-depth investigation of the region's economic condition and the critical requirements necessary to improve its economic vitality, as documented in "Cleveland Tomorrow—A Strategy for Economic Vitality", December 1981.

Organization

Cleveland Tomorrow consists of a Board and a Steering Committee of Chief Executive Officers to oversee the overall effort. Cleveland Tomorrow task forces, or liaisons with other organizations, have been created to implement each of the six programs. Task forces are chaired by a chief executive officer and include other relevant participants (including people not on the Board) as required to implement that specific program. Cleveland Tomorrow has a full-time staff of three people to assist in its activities.

CATERPILLAR TRACTOR CO.,
Peoria, Illinois, September 9, 1983.

Ms. CHERYL COOLEY,
Counsel, Senate Commerce Committee,
427 Hart Senate Office Building, Washington, D.C.

DEAR MS. COOLEY: A review of my files fails to show any subsequent correspondence from Senator Gorton in which a follow-up question was raised. However, let me answer his inquiry at this time:

Question. Other witnesses have identified barriers, or in some cases simply a lack of close ties, between industry and the university research community. These barriers, or lack of ties, appear to restrict the flow of manufacturing innovation. Would S. 1286 help overcome these barriers? What other legislative changes would you suggest to address these barriers or to create closer cooperation?

Answer. As I indicated in my testimony, Caterpillar Tractor Co. strongly endorses S. 1286. We believe enactment of the legislation will facilitate a closer working relationship between industry and research institutions. Targeting programs in applied research should help accelerate development of manufacturing technologies for specific industrial sectors.

We believe the five-year program as outlined in S. 1286 is sound and should be implemented as quickly as possible. While recognizing that additional modification to the Department of Commerce programs may be necessary in the long term, we would recommend that the Committee report S. 1286 without substantive amendments. We believe it will contribute significantly to the development of new innovative manufacturing technologies which are essential to maintaining our industrial productivity.

Let me again thank the Subcommittee and Chairman Gorton for the opportunity to testify. I hope my comments will prove helpful as work continues on S. 1286.

Sincerely,

DONALD DOMNICK,
Vice President.

AMERICAN FEDERATION OF LABOR AND
CONGRESS OF INDUSTRIAL ORGANIZATIONS,
Washington, D.C., September 13, 1983.

Hon. SLADE GORTON,
Chairman, Subcommittee on Science, Technology and Space,
U.S. Senate, Washington, D.C.

DEAR SENATOR GORTON: Enclosed is Arnold Cantor's answer to the question you posed to the industry panel during the hearings on "The Role of Technology in Promoting Industrial Competitiveness" before the Subcommittee on Science, Technology and Space.

Question. Other witnesses have identified barriers or, in some cases, simply a lack of close ties between industries and the university research community. These barriers, or lack of ties, appear to restrict the flow of manufacturing innovation. Would S. 1286 help overcome these barriers? What other legislative changes would you suggest to address these barriers or to create closer cooperation?

Answer. I'm not familiar with all the issues that have been raised in terms of the problems in the relationship between universities and private corporations conducting related research, but S. 1286 does contain a flexible mechanism to fund different kinds of research facilities and has the potential to draw university and private researchers together in cooperative research in many instances.

Sincerely yours,

BILL CUNNINGHAM,
Economist, Department of Economic Research.

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